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(71) Applicant:
PIRELLI PNEUMATICI SOCIETA' PER AZIONI
20126 Milano (IT)

(72) Inventors:
• Caretta, Renato
Gallarate (Varese) (IT)

• Mariani Florenzo
20046 Biassono (IT)

(74) Representative:
Righetti, Giuseppe et al
Bugnion S.p.A.
Viale Lancetti, 19
20158 Milano (IT)

Remarks:

In accordance with the last part of Article 14 (2) EPC the applicant has filed a text with which it is intended to bring the translation into conformity with the original text of the application.

(54) A method for making tyres for vehicle wheels

(57) At least one carcass ply (3) is formed by depositing a strip-like element (13) comprising longitudinal thread-like elements (13a) incorporated into a layer of elastomer material (13b), onto a toroidal support (11). Deposition of the strip-like element (13) takes place in alternated deposition sections (23, 24) each comprising two radially-extending side portions (23a, 24a, 23c, 24c) and a crown portion (23b, 24b) extending at a radially external position. The side portions of each deposition section (23, 24) are at least partly overlapped with side portions belonging to an adjacent deposition section. Associated with the carcass ply (3) are annular structures (4) comprising a circumferentially inextensible annular insert (32) axially external to an anchoring element (31). A belt structure (5), a tread band (8) and sidewalls (9) are combined with the thus formed carcass structure (2) to define a tyre (1) to be submitted to a vulcanization step.

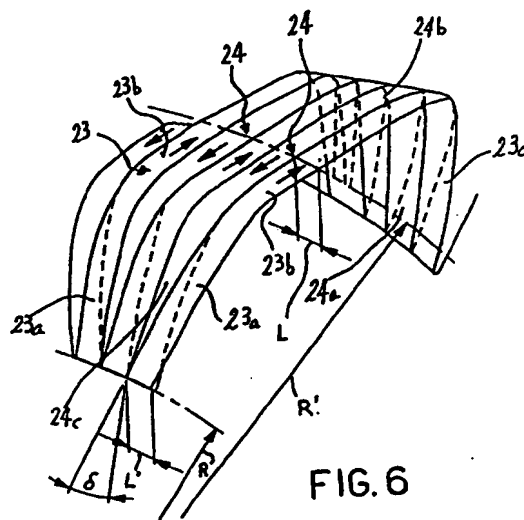


FIG. 6

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Description

[0001] The present invention relates to a method of making tyres for vehicle wheels, comprising the steps of: manufacturing a carcass structure; applying a belt structure to the carcass structure at a circumferentially external position thereof; applying a tread band to the belt structure at a circumferentially external position thereof; applying at least one pair of sidewalls to the carcass structure at laterally opposite positions; vulcanizing the obtained tyre.

[0002] Manufacture of tyres for vehicle wheels involves formation of a carcass structure essentially consisting of one or more carcass plies substantially having a toroidal conformation and the axially opposite side edges of which engage respective circumferentially inextensible annular reinforcing elements called "bead cores".

[0003] Applied to the carcass structure, at a circumferentially external position thereof, is a belt structure comprising one or more belt strips in the form of a closed ring, essentially consisting of textile or metal cords suitably oriented relative to each other and to the cords belonging to the underlying carcass plies.

[0004] A tread band currently consisting of a strip of elastomer material of appropriate thickness is applied to the belt structure, at a circumferentially external position thereof. It is to point out that, to the aims of the present invention, by the term "elastomer material" it is intended a rubber blend in its entirety, that is the assembly made up of a base polymer suitably amalgamated with mineral fillers and/or additives of any other type.

[0005] Finally, to the opposite sides of the tyre being manufactured a pair of sidewalls are applied, each of them covering a side portion of the tyre included between a so-called shoulder region, located close to the corresponding side edge of the tread band, and a so-called bead located at the corresponding bead core.

[0006] In accordance with traditional production methods, essentially the above listed tyre components are first made separately from each other to be then assembled during a tyre-manufacturing step.

[0007] For instance, for making the carcass ply or plies to be associated with the bead cores to form the carcass structure, production of a rubberized fabric comprising longitudinally-disposed continuous textile or metallic cords, through an extrusion and/or calendering process, is first required. This rubberized fabric is submitted to a transverse-cutting operation to produce lengths of predetermined sizes that are subsequently joined together so as to give rise to a continuous ribbon-like semifinished product having transversely-disposed parallel cords.

[0008] Then this article of manufacture is to be cut into pieces the length of which is correlated with the circumferential extension of the carcass to be made.

[0009] Production methods have been recently proposed which, instead of resorting to the production of

semifinished products, make the carcass structure directly during the tyre-manufacturing step.

[0010] For example, US Patent 5,453,140 herein quoted as an example of the most pertinent state of the art, discloses a method and an apparatus according to which the carcass structure is formed by laying down a single continuous thread according to alternating deposition paths placed consecutively in side by side relationship in a circumferential direction, onto a toroidal support having a shape corresponding to the inner shape of the tyre to be made.

[0011] In more detail, the toroidal support is previously coated with a raw-rubber layer having a dual function, i.e. that of conveniently adhering to the deposited thread so as to hold the individual deposition sections thereof at a fixed positioning, and that of forming an air-proof inner liner in the finished tyre.

[0012] The individual thread, directly drawn from a reel, is engaged by sliding members leading it to a movable guide member operating at the toroidal support. The movable guide member moves in a sliding path of travel having an advance section and a return section mutually interconnected to form an endless line lying in a plane radial to the toroidal support. Each of the advance and return sections extends in a substantially C-shaped configuration around the profile in transverse section of the toroidal support.

[0013] In this way, each time the guide element covers one of the advance or return sections of the sliding path of travel, deposition of the thread onto the toroidal support is caused, thereby forming a deposition section extending in a U-shaped conformation around the profile in transverse section of the toroidal support itself.

[0014] At the instant intervening between formation of a deposition section and formation of the subsequent deposition section, the toroidal support is rotated through a predetermined angular pitch, making the apparatus ready for formation of a new deposition section disposed circumferentially in side by side relationship with the previously deposited section.

[0015] Pick-up devices making use of fork-shaped elements engage the thread at the end region of the just-formed deposition section, to prevent dragging along of the latter by the guide member during the initial formation step of the subsequent deposition section. Retention devices making use of presser elements conveniently act at the transition region between two deposition sections in succession to cause the end flaps thereof to adhere to the side surface of the toroidal support.

[0016] Tyres obtained by this production method have a carcass structure in which the cords forming the carcass ply or plies consist of a single thread-like element forming a plurality of consecutive sections transverse to the tyre, disposed parallelly in side-by-side relationship in a circumferential direction and deposited in respectively opposite directions so as to define an alternated course.

[0017] Within the scope of the carcass structure manufacture, as can be learnt from Patents EP 0 664 231 and EP 0 664 232, the deposition sections formed by the individual thread-like element are also provided to be placed in an alternated sequence at axially opposite positions relative to one or more annular anchoring elements constituting said bead cores.

[0018] In accordance with the present invention, within the tyre-manufacturing scope, different advantages have been found to be achieved if the carcass ply or plies are made by depositing at least one strip-like element essentially comprising a layer of raw elastomer material incorporating two or more parallel thread-like elements disposed longitudinally, in alternated consecutive sections transverse to the tyre.

[0019] In more detail, the invention relates to a method of making a tyre for vehicle wheels, characterized in that manufacturing of the carcass structure involves formation of at least one carcass ply by the following steps: preparing at least one continuous strip-like element comprising a plurality of longitudinal and parallel thread-like elements at least partly coated with at least one layer of raw elastomer material; depositing the strip-like element onto a toroidal support in alternated deposition sections each extending according to a substantially U-shaped conformation about the profile in transverse section of the toroidal support, to define two side portions substantially extending in planes orthogonal to a geometric axis of rotation of the toroidal support at mutually spaced apart positions in an axial direction, and a crown portion extending in a radially external position between the side portions, the crown portions of each deposition section being disposed consecutively in side by side relationship along the circumferential extension of the toroidal support, whereas the side portions of each deposition section are each partly overlapped with a side portion of at least one consecutive deposition section.

[0020] In more detail, the side portions in mutual-overlapping relationship are caused to mutually converge at the geometric axis of rotation of the toroidal support.

[0021] Advantageously, mutual overlapping of the side portions of the deposition sections progressively decreases starting from a maximum value at the radially inner ends of the side portions until a zero value at transition regions between said side portions and crown portions.

[0022] Preferably, the side portions in mutual-overlapping relationship are maintained joined to each other at a bending end region where the strip-like element is folded upon itself.

[0023] In a preferential solution the individual deposition sections are sequentially laid down onto the toroidal support according to a circumferential distribution pitch corresponding to the width of the strip-like element.

[0024] In accordance with a possible alternative embodiment, the individual deposition sections are sequentially laid down onto the toroidal support accord-

ing to a circumferential distribution pitch corresponding to a multiple of the width of the strip-like element. Preferably, the strip-like element has a width corresponding to a submultiple of the circumferential extension of the toroidal support, as measured at its equatorial plane.

[0025] According to a further aspect of the invention, manufacturing of said at least one carcass ply further involves a sequential pressing step of the strip-like element at the side portions of the deposition sections, to define regions of greater width close to the inner circumferential edges of the carcass structure.

[0026] Said pressing step is preferably carried out on the strip-like element directly during the deposition step, by exerting a pressing action of the strip-like element at a section thereof upstream of the toroidal support.

[0027] Concurrently with said pressing step, moving apart from each other of the thread-like elements comprised in the strip-like element is carried out.

[0028] During the deposition step, at least one deposition section comprising an initial or leading end of the strip-like element may be advantageously retained on the toroidal support by a suction action produced through the toroidal support itself.

[0029] In particular, formation of each deposition section involves the steps of: guiding the strip-like element on a distributor element movable about the profile in transverse section of the toroidal support; translating the distributor element substantially radially away from the geometric axis of rotation of the toroidal support to form a first side portion of the deposition section of the strip-like element; rotating the toroidal support relative to the distributor element according to an angular pitch corresponding to half the distribution pitch of the deposition sections, concurrently with formation of said first side portion; translating the distributor element substantially in a direction parallel to the geometric axis of rotation of the toroidal support to form the crown portion of the deposition section of the strip-like element; translating the distributor element substantially radially close to the geometric axis of rotation of the toroidal support to form a second side portion of the deposition section of the strip-like element; rotating the toroidal support relative to the distributor element according to said angular pitch, concurrently with formation of said second side portion.

[0030] Preferably, during formation of the first side portion of each deposition section the step of retaining the strip-like element at a bending region defined between the first side portion and the second side portion of the previously formed deposition section is carried out.

[0031] This retaining step of the strip-like element is for example carried out by disposing a retaining element alongside the second side portion after translation of the distributor element radially close to the geometric axis of rotation of the toroidal support, so that the strip-like element is turned back about the retaining element thereby forming the bending region as a result of trans-

lation of the distributor element radially away from the geometric axis of rotation of the toroidal support.

[0032] It is also preferably provided that the retaining element should be axially disengaged from the bending region, after starting of formation of the crown portion of the deposition section being made.

[0033] Accomplishment of a pressing step of said side portions of the deposition sections against side walls of the toroidal support may be also provided.

[0034] This pressing step is preferentially carried out repeatedly on a first and a second side portions belonging to two contiguous deposition sections.

[0035] Advantageously, accomplishment of the carcass structure further comprises the step of applying at least one inextensible annular structure to an area close to each of the inner circumferential edges of the carcass ply obtained from the deposition step.

[0036] Accomplishment of the carcass structure may further comprise the step of turning back end flaps of the side portions about the respective inextensible annular structures.

[0037] In accordance with a further innovatory aspect of the invention, that can be also advantageously adopted independently of the above listed innovatory features, accomplishment of each inextensible annular structure comprises the steps of: depositing at least one thread-like element in concentric coils into a moulding cavity to form a circumferentially inextensible annular insert to be positioned substantially parallelly to adjacent surfaces of the carcass ply; positioning an annular anchoring element into the moulding cavity, at a position axially close to the circumferentially inextensible annular insert; injecting raw elastomeric material into the moulding cavity to make a filling body intimately joined to the annular anchoring element and the circumferentially inextensible annular insert.

[0038] Said deposition step may be conveniently preceded by a rubberizing step in which said thread-like element is coated with at least one layer of raw elastomer material.

[0039] Preferably, also provided is a step of magnetically retaining the circumferentially inextensible annular insert, at a predetermined position, within the moulding cavity.

[0040] Injection of the raw elastomer material may be advantageously carried out through at least one circumferential admission opening or hollow space opening into the moulding cavity.

[0041] According to a possible embodiment, accomplishment of the carcass structure further comprises the step of forming a second carcass ply in the same manner as formation of the first carcass ply.

[0042] In accordance with a further aspect of the invention, to be utilized too independently of the above statements, application of the belt structure comprises the steps of: forming at least one continuous belt ribbon comprising at least one layer of raw elastomer material at least partly incorporating a plurality of longitudinal

parallel cords; cutting said continuous belt ribbon according to a predetermined inclination relative to its longitudinal extension to form belt lengths having a predetermined size in width, measured perpendicularly to the cutting direction; laying down the belt lengths consecutively in circumferential alignment onto the carcass structure to form at least one first continuous belt strip having said cords disposed transversely according to an inclination corresponding to the cutting inclination of said lengths.

[0043] Before said cutting step, the continuous belt ribbon may be possibly submitted to a calendaring step to give said lengths a circumferential size corresponding to a submultiple of the circumferential extension of the belt strip.

[0044] Application of the belt structure preferentially further comprises the step of forming at least one second belt strip by winding of at least one continuous thread-like element in coils disposed axially in side by side relationship and extending circumferentially about the first belt strip.

[0045] If required, the winding coils formed by the elongated element can be disposed mutually in side by side relationship according to a variable axial-distribution pitch, which is for example greater close to the equatorial median plane of the toroidal support relative to the opposite side edges of the belt structure.

[0046] Advantageously, application of the tread band may comprise the step of circumferentially wrapping at least one continuous sheet of raw elastomer material about the belt structure in a plurality of radially superposed coils.

[0047] Preferably, said continuous sheet of elastomer material is produced simultaneously with its application to the belt structure.

[0048] Width of the elastomer-material sheet may be advantageously provided to be progressively reduced concurrently with formation of each winding coil about the belt structure.

[0049] In accordance with a further independent aspect of the invention, each of said sidewalls is preferably made by injection of elastomer material into a mould.

[0050] In more detail, accomplishment of each of said sidewalls may comprise the following steps: injecting a first elastomer material into a first cavity defined in said mould to form a radially outer portion of the sidewall; defining a second cavity in the mould, which is partly delimited by the radially outer portion of the sidewall; injecting a second elastomer material into the second cavity of the mould to define a radially inner portion of the sidewall.

[0051] Formation of the carcass ply may be preceded by a step of coating the toroidal support with at least one air-proof layer or liner of elastomer material.

[0052] This coating step is advantageously carried out by winding at least one ribbon-like band of an air-proof elastomer material in coils disposed in side-by-side

relationship along the profile in transverse section of the toroidal support.

[0053] In addition to, or in place of the formation of the air-proof liner, before the vulcanization step the following steps are carried out: disengaging the tyre from the toroidal support; inserting an air tube into the carcass structure.

[0054] During said vulcanization step, a step of stretching said carcass plies and belt strips may be advantageously carried out for achieving an expansion of the tyre of a linear amount included between 2% and 5%.

[0055] Further features and advantages will be best understood from the detailed description of a preferred but non-exclusive embodiment of a method of manufacturing a tyre for vehicle wheels according to the present invention. This description will be given hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 is a fragmentary perspective view in split of a tyre obtained in accordance with the present invention;
- Figs. 2 and 3 diagrammatically show an apparatus for making the carcass ply, in different operating steps respectively, seen in a direction orthogonal to a diametrical section plane of a toroidal support carrying the tyre during the manufacturing step;
- Fig. 4 is a diagram showing the manufacture of a strip-like element intended for forming the carcass ply or plies;
- Fig. 5 shows an embodiment of said strip-like element in transverse section;
- Fig. 6 is a fragmentary perspective view diagrammatically showing the deposition sequence of a strip-like element for the purpose of forming a carcass ply of the tyre in accordance with the invention;
- Fig. 7 is a fragmentary diametrical section view of an inextensible annular structure to be inserted at the tyre bead, during a moulding step for manufacturing the tyre;
- Fig. 8 is a fragmentary perspective view of an inextensible annular structure laterally applied to the carcass ply;
- Fig. 9 is a diagram showing accomplishment of a continuous ribbon and cutting of same into lengths of predetermined shape and sizes for making a first belt strip;
- Fig. 10 is a transverse section view of said continuous belt ribbon;
- Fig. 11 is a fragmentary perspective view showing deposition of the ribbon lengths in a circumferential alignment onto the carcass structure for formation of said first belt strip;
- Fig. 12 is a diagram referring to production of a rubberized elongated element intended for making a second belt strip;

- Fig. 13 is a fragmentary perspective view in section showing the step of forming said second belt strip by the continuous elongated element;
- Fig. 14 is a diagram showing formation of a continuous elastomer sheet intended for making a tread band;
- Fig. 15 is a fragmentary perspective view in section showing the tread band made by winding the continuous sheet in several superposed coils;
- Fig. 16 diagrammatically shows formation of the tyre sidewalls in transverse section;
- Fig. 17 is a fragmentary perspective view showing application of the sidewalls to the tyre during its manufacturing step;
- Fig. 18 is a fragmentary perspective view in section showing the tyre in reference provided with an inextensible annular structure made in accordance with a possible alternative embodiment of the invention;
- fig. 19 is a transverse half-section showing a tyre in accordance with the invention mounted on a respective rim and in a condition of slip run.

[0056] With reference to the cited drawings and in particular to Figs. 1 and 17, a tyre for vehicle wheels made by a method in accordance with the present invention has been generally identified by reference numeral 1.

[0057] Tyre 1 essentially comprises a carcass structure 2 having at least one carcass ply 3 substantially of a toroidal conformation and engaged, by its opposite circumferential edges, with a pair of inextensible annular structures 4 that, when the tyre is completed, are located in the region usually identified as "bead".

[0058] Applied to the carcass structure 2, at a circumferentially outer position, is a belt structure 5 comprising one or more belt strips 6, 7. A tread band 8 is circumferentially superposed on the belt structure 5 and longitudinal and transverse cuts 8a are formed in said tread band 8, following a moulding operation carried out concurrently with the tyre vulcanization, and such disposed as to define a desired "tread pattern".

[0059] The tyre also comprises a pair of so-called "sidewalls" 9 applied laterally to opposite sides of the carcass structure 2.

[0060] The carcass structure 2 may possibly be coated, on its inner walls, with an air-proof elastomer-material layer 10, i.e. a so-called "liner", essentially consisting of a layer of elastomer material impervious to air, adapted to ensure the hermetic seal of the inflated tyre.

[0061] Assembling of the above listed components, as well as production of one or more of said components, takes place with the aid of a toroidal support 11, diagrammatically shown in Figs. 2 and 3, having the same configuration as the inner walls of the tyre to be manufactured.

[0062] In a preferential solution the toroidal support 11 has reduced sizes relative to those of the finished tyre, according to a linear amount preferably included between 2% and 5%, measured, just as an indication,

along the circumferential extension of the support itself at an equatorial plane X-X thereof which is coincident with the equatorial plane of the tyre itself.

[0063] The toroidal support 11, which is not described or illustrated in detail in that it is not particularly of importance to the purposes of the invention, may for example consist of a collapsible drum or an inflatable chamber or bladder suitably reinforced so that it may take and maintain the desired toroidal conformation under inflation conditions.

[0064] After taking into account the above statements, manufacture of tyre 1 first involves formation of the carcass structure 2 starting with possible formation of the air-proof layer or liner 10.

[0065] This liner 10 can be advantageously made by circumferentially winding about the toroidal support 11, at least one ribbon-like band 12 of air-proof elastomer material, produced from an extruder and/or a calender located close to the toroidal support itself. As viewed from Fig. 1, winding of the ribbon-like band 12 substantially takes place in circumferential coils disposed consecutively in side by side relationship to follow the profile in transverse section of the outer surface of the toroidal support 11.

[0066] For descriptive purposes, by "profile in transverse section" it is herein intended a configuration exhibited by the half-section of the toroidal support 11 sectioned along a plane radial to a geometric rotation axis thereof, not shown in the drawings, which is coincident with the geometric axis of rotation of the tyre being manufactured.

[0067] Concurrently with winding of the ribbon-like band 12, application of a pair of auxiliary annular elements 12a can be carried out close to the inner circumferential edges of the carcass structure during its manufacturing step. Each of these auxiliary annular elements 12a can be obtained for example by winding the ribbon-like band 12 in a coil disposed axially side by side with the corresponding coil located at the inner perimetric edge of liner 10 defined or to be defined on the toroidal support 11. Alternatively, the auxiliary annular elements 12a can be made up of at least one auxiliary ribbon-like band obtained from a respective extruder located at the toroidal support 11.

[0068] In accordance with the present invention, the carcass ply 3 is directly formed on the toroidal support 11 by depositing thereon, following alternating paths, at least one strip-like element 13 preferably having a width included between 3 mm and 15 mm, as better clarified in the following.

[0069] As shown in Fig. 4, preparation of the strip-like element 13 essentially involves that two or more thread-like elements 13a, and preferably three to ten thread-like elements 13a, fed from respective reels 14, should be guided through a first extruder 15 associated with a first extrusion apparatus 16 carrying out feeding of raw elastomer material through the extruder itself.

[0070] It is pointed out that, in the present description

by "extruder" it is intended that part of the extrusion apparatus also identified in this particular field by the term "extrusion head", provided with a so-called "die" passed through by the product being worked at an outlet port shaped and sized according to the geometrical and dimensional features to be given to the product itself.

[0071] The elastomer material and thread-like elements 13a are intimately joined together within the extruder 15, thereby generating the continuous strip-like element 13 at the outlet thereof, which element is formed of at least one layer of elastomer material 13b in the thickness of which the thread-like elements themselves are incorporated.

[0072] Depending on requirements, it is possible to guide the thread-like elements 13a in the extruder 15 in such a manner that they are not integrally incorporated into the layer of elastomer material 13b but appear on one or both surfaces thereof.

[0073] The thread-like elements 13a may each consist for example of a textile cord preferably having a diameter included between 0.6 mm and 1.2 mm, or a metallic cord preferably having a diameter included between 0.3 mm and 2.1 mm.

[0074] Advantageously, if required, the thread-like elements 13a can be disposed in the strip-like element 13 in such a manner that they give the carcass ply 3 thus obtained unexpected qualities of compactness and homogeneity. For the purpose, the thread-like elements 13a can be for example disposed according to a density greater than six thread-like elements/centimetre, measured circumferentially on the carcass ply 3 close to the equatorial plane X-X of tyre 1. In any case it is preferably provided that the thread-like elements 13a should be disposed in the strip-like element 13 according to a mutual distance between centres not lower than 1.5 times the diameter of the thread-like elements themselves, in order to enable an appropriate rubberizing operation between the adjacent threads.

[0075] The continuous strip-like element 13 coming out of extruder 15 can be advantageously guided, optionally through a first accumulator-compensator device 17, on a deposition apparatus 18 diagrammatically shown in Figs. 2 and 3.

[0076] The deposition apparatus 18 essentially comprises first guide members 19, consisting for example of a pair of rollers borne on stationary rotation axes, arranged to engage the continuous strip-like element 13 produced by the extruder 15. Downstream of the first guide members 19, the strip-like element 13 comes into engagement with second guide members 20 consisting of further rollers for example, mounted on a carriage 21 reciprocating in a direction oriented transversely to the equatorial plane X-X of the toroidal support 11. Slidably linked to the movable carriage 21, in a direction substantially perpendicular to the movement direction of the carriage itself, is at least one distributor element 22 consisting of a further roller, for example.

[0077] Components intended for mutual connection and movement of the distributor element 22 and movable carriage 21 are not shown in the accompanying drawings in that they can be made in any manner convenient to a person skilled in the art, and in any case they are not of importance to the aims of the present invention.

[0078] By a combination between the transverse movement of carriage 21 and radial movement of the distributor element 22, the distributor element lends itself to be translated by a reciprocating motion along a trajectory "t" extending according to a substantially U-shaped conformation about the profile in transverse section of the toroidal support 11.

[0079] The toroidal support 11 can be driven in angular rotation in a step-by-step movement in synchronism with the movement of the distributor element 22, in such a manner that the strip-like element 13 is deposited onto the toroidal support in consecutive deposition sections 23, 24, transverse to the tyre, disposed parallelly in side-by-side relationship in a circumferential direction and according to respectively opposite directions, so as to define an alternating course.

[0080] In more detail, each of the deposition sections 23, 24 extends in a U-shaped conformation about the profile in transverse section of the toroidal support 11, to define two side portions 23a, 23c, 24a, 24c substantially extending in planes orthogonal to the geometric axis of rotation of the toroidal support, at mutually spaced apart positions in an axial direction, and a crown portion 23b, 24b extending at a radially outer position relative to the side portions 23a, 23c, 24a, 24c.

[0081] For convenience in description, the deposition sections obtained as a result of a translation from right to left of the deposition member 22 with reference to Figs. 2 and 3, will be hereinafter referred to as first deposition sections 23. Those obtained from translation of the distributor element in the opposite direction will be, instead, identified as second deposition sections 24.

[0082] In more detail, the deposition sequence of the strip-like element 13 on the toroidal support 11 is the following.

[0083] Starting is assumed to take place from an initial situation in which, as shown in Fig. 2, the distributor element 22 is located in its lefthand end-of-stroke position of its movement trajectory "t". Starting from this position, the distributor element 22 is substantially translated radially away from the geometric axis of rotation of the toroidal support 11, to form a first side portion 23a of the first deposition section 23.

[0084] Due to the sticky character of the raw elastomer material forming layer 13b coating the thread-like elements 13a, a steady adhesion of the strip-like element 13 on the surfaces of the toroidal support 11 is ensured, even in the absence of liner 10 on the toroidal support itself. In the case that, as diagrammatically shown in Figs. 2 and 3, the toroidal support 11 has side portions 11a of a concave profile, located in the regions

corresponding to the sidewalls of the tyre being produced, the above described adhesion takes place as soon as the strip-like element 13 comes into contact with the toroidal support itself at a radially external region of its profile in transverse section.

[0085] In addition to or in place of the above described exploitation of the natural sticky character of the elastomer material, retention of the strip-like element 13 on the toroidal support 11 can be obtained by carrying out a suction action produced through one or more appropriate holes 28 arranged on the toroidal support.

[0086] In the initial step of the distributor-element stroke 22 away from the geometric axis of rotation of the toroidal support 11, the strip-like element 13 is folded upon itself forming a bending region 25 representing a transition between the first side portion 23a of the deposition section 23 which is about to be formed and a second side portion 24b belonging to a previously formed deposition section 24. During formation of the first side portion 23a, the strip-like element 13 is conveniently retained at said bending region 25, by a retention element 26 (Fig. 3) engaging in the bending region in a manner better described in the following.

[0087] Concurrently with formation of the first side portion 23a, the toroidal support 11 is rotated about its own geometric axis of rotation relative to the distributor element 22, according to an angular pitch corresponding to half the circumferential distribution pitch of the deposition sections 23, 24. Consequently, the first side portion being formed will take a correspondingly inclined orientation relative to the direction of movement performed by the distributor element 22 away from the geometric axis of rotation of the support itself.

[0088] In the embodiment diagrammatically shown in Fig. 2, where the circumferential distribution pitch of the individual deposition sections 23, 24 corresponds to the width of the strip-like element 13, the angular-rotation pitch of the toroidal support 11 will correspond to half the width of the strip-like element itself.

[0089] In any case, the circumferential distribution pitch of the deposition sections 23, 24 may be provided to correspond to a multiple of the width of the strip-like element 13. In this case, the angular-movement pitch of the toroidal support 11 will in any case correspond to half said circumferential distribution pitch. It is to point out that, to the aims of the present invention, when it is not otherwise stated, the term "circumferential" refers to a circumference lying in the equatorial plane X-X and close to the outer surface of the toroidal support 11.

[0090] When the support element 22 comes close to the top of its stroke away from the geometric axis of rotation of the toroidal support 11, the movable carriage 22 is translated in its movement direction from left to right with reference to Fig. 2. Under this circumstance, the distributor element 22 moves in a direction substantially parallel to the geometric axis of rotation of the toroidal support 11 in such a manner that, in a position radially external to the latter, there is formation of a

crown portion 23b of the deposition section 23 being made.

[0091] When carriage 21 has substantially completed its translation stroke, the distributor element 22 is moved substantially radially close to the geometric rotation axis of the toroidal support 11. Under this circumstance a second side portion 23c of the first deposition section 23 is formed.

[0092] Concurrently with formation of this second side portion 23c, the toroidal support 11 is rotated relative to the distributor element 22 at an angular pitch identical with the one previously performed.

[0093] When the distributor element 22 is about to complete its stroke of moving close to the geometric rotation axis of the toroidal support 11, a further retention element (not shown) identical with the previously mentioned retention element 26 and in mirror image relationship therewith is disposed alongside the second side portion 23b which has been just formed, in the same manner as shown in chain line in Fig. 3 in connection with the retention element 26 located on the laterally opposite side.

[0094] Preferably, the retention element 26 is then laterally moved close to the toroidal support 11, to enable passage of the distributor element 22 during its upward movement, as a result of which, concurrently with formation of a first side portion 24a of a new second deposition section 24, the strip-like element 13 will be turned back about the retention element thereby forming a new bending region 25.

[0095] Simultaneously with formation of the first side portion 24a of the second deposition section 24, the toroidal support 11 performs a new angular-rotation step that, being added to the angular step performed during deposition of the second side portion 23b of the first deposition section 23, makes the distributor element 22 ready to form the crown portion 24b of the second deposition section 24 at a position spaced apart from the previously formed deposition section 23 according to the desired circumferential distribution pitch.

[0096] The retention element 26 is axially disengaged from the bending region 25 after formation of the crown portion 24b has begun. Actually, in this step the assurance exists that the strip-like element 13 has come into contact with the surface of the toroidal support 11 at a point downstream of the just-formed first side portion 24a, and that it is not liable to carry out undesired displacements that could impair the deposition geometry of the strip-like element.

[0097] Once the retention element 26 has been drawn out of the bending region 25, the side portions 23c, 24c of the deposition sections 23, 24 can be submitted to a pressing step against the side walls of the toroidal support 11. For the purpose, a pair of presser rollers 27 or equivalent means may be provided, and they operate on opposite sides of the toroidal support 11 and are each arranged so as to repeatedly operate on the first

and second side portions belonging to two contiguous deposition sections.

[0098] Only one of these presser rollers 27 has been diagrammatically shown in Fig. 3.

[0099] The above described operating sequence of the deposition apparatus 18 enables the crown portions 23b, 24b of each deposition section 23, 24 in the obtained carcass ply 3 to be disposed consecutively in side by side relationship along the circumferential extension of the toroidal support 11, whereas the side portions 23a, 23c, 24a, 24c of each deposition section 23, 24 are each disposed in superposition relationship with a side portion of at least one consecutive deposition section. More specifically, the first side portion 23a, 24a of each deposition section 23, 24 is partly superposed on the second side portion 23c, 24c of the previously formed deposition section 23, 24.

[0100] As clearly shown in Fig. 6, the side portions 23a, 24c in mutual superposition relationship move towards each other substantially in the direction of the geometric axis of rotation of the toroidal support 11, according to an angle δ the value of which is correlated with the width "L" of the strip-like element 23, 24, and in any case with the circumferential distribution pitch of the deposition sections 23, 24, as well as the difference between a maximum radius R' and a minimum radius R to be measured at a point of maximum distance and a point of minimum distance respectively from the geometric axis of rotation of the toroidal support 11.

[0101] Due to the mutual convergence between the first and second contiguous side portions 23a, 24c and 24a, 23c, mutual superposition of the same is progressively decreasing starting from a maximum value at the radially inner ends of the side portions, where said portions mutually meet at the bending region 25, until a zero value at the transition region between the side portions and crown portions 23b, 24b.

[0102] It is to note that, due to the difference between the minimum and maximum radii R and R' , the average density of the thread-like elements 13a, i.e. the amount of the thread-like elements present in a circumferential section of given length, would have a tendency to progressively increase on moving close to the geometric rotation axis of the toroidal support 11.

[0103] Actually, this increase in density is proportional to the ratio value between the maximum radius R' and minimum radius R .

[0104] However, in the tyre made in accordance with the present invention, mutual superposition of side portions 23a, 24c and 24a, 23c actually gives rise to halving of the average density to be measured along the inner circumferential edges of the obtained carcass ply 3, i.e. at the bending regions 25.

[0105] Under this circumstance, the bending portions 25 would be mutually joined in the circumferential direction, giving rise to a homogeneous distribution of the thread-like elements 13a along the inner circumferential edges of the carcass ply 3, only if ratio between the

maximum diameter R' and minimum diameter R corresponds to 2.

[0106] When, on the contrary, as it usually occurs, the ratio value between the maximum radius R' and minimum radius R is less than 2, the bending portions 25 would tend to arrange themselves according to a circumferential distribution pitch greater than the width of the strip-like element 13, thus giving rise to empty spaces between one bending region 25 and another one.

[0107] If the presence of these empty spaces is wished to be avoided, so as to consequently obtain a maximum structural homogeneity of the carcass ply 3 close to the inner circumferential edges of the carcass ply 3, a pressing step is provided to be sequentially executed on the strip-like element 13 at the regions of its longitudinal extension corresponding to the side portions 23a, 23c, 24a, 24c, so as to define regions of increased width l' on the extension of the strip-like element, which regions are located at the inner circumferential edges of the formed carcass ply 3.

[0108] Said pressing action can be carried out by a presser roller 29 mounted on the movable carriage 21 for example, and adapted to be selectively set in motion by an actuator 30 to press the strip-like element 13 against one of the rollers being part of the second transportation unit 20.

[0109] Actuator 30 is sequentially activated during deposition of the strip-like element 13, so as to cause crushing of same at the sections of longitudinal extension intended to form the side portions 23a, 23c, 24a, 24c. Thrust exerted by actuator 30 can be conveniently established in order to obtain an increasingly growing crushing action for example on moving close to the bending regions 25 and a progressively decreasing action on moving away therefrom. The crushing action causes a reduction in the thickness of the elastomeric layer 13b and an increase in the width of the strip-like element 13 which, as a result, will cause the thread-like elements 13a to move apart from each other.

[0110] By conveniently measuring the thrust action exerted by the actuator, width of the strip-like element 13 can be increased until an amount L' involving mating of each bending region 25 with the adjacent bending regions.

[0111] By suitably inclining the orientation of the geometric axis of rotation of the toroidal support 11 relative to the movement direction of the movable carriage 21, the crown portions 23b, 24b of the deposition sections 23, 24 can be given a desired inclination, preferably included between 0° and 15° and more preferably of 3° , relative to a radial plane passing by the geometrical axis. It is also to note that, due to the rotation steps carried out by the toroidal support 11 concurrently with the formation of each deposition section 23, 24, the side portions 23a, 23c, 24a, 24c of the deposition section will be inclined at an angle of $\delta/2$ relative to a radial plane crossing the side portions themselves, the first side por-

tions 23a, 24a having an opposite inclination direction with respect to the second side portions 23c, 24c.

[0112] Accomplishment of a carcass structure 2 generally comprises the step of applying said inextensible annular structure 4 to an area close to each of the inner circumferential edges of the carcass ply 3 obtained in the previously described manner, for the purpose of creating the carcass regions, known as "beads", which are specifically intended for ensuring anchoring of the tyre to a corresponding mounting rim; in accordance with a preferred embodiment of the tyre, the carcass ply thereof is obtained in the above described manner.

[0113] Each of these inextensible annular structures 4 (Fig. 7) comprises an annular anchoring element 31, of the type usually called "bead core", which can be made up, for example, of one or more metallic wires twisted together or wound in side-by-side coils to define a profile of substantially circular or quadrangular transverse section.

[0114] In accordance with a preferred embodiment, to be also advantageously associated with the present invention, a circumferentially inextensible annular insert 32 is combined with the bead core 31 and it approximately extends in a plane parallel to the adjacent surfaces of the carcass ply 3 along a radial extension determined by the difference between the minimum inner radius and the maximum outer radius of the annular insert, preferably equal to at least twice the radial extension of the bead core 31 or in any case greater than the latter.

[0115] In a first embodiment shown in Figs. 1, 8, 15, 17 and 19, the inextensible annular insert 32 is located at an axially outer position relative to the bead core 31. In other words, the annular insert 32 is located, with respect to the bead core 31, at a laterally opposite position relative to the equatorial plane X-X.

[0116] In a possible alternative solution, shown in Fig. 18, the inextensible annular insert 32 is, on the contrary, located at an axially inner position relative to the bead core 31, i.e. on the side facing the equatorial plane X-X. In this case, the annular insert 32 preferably substantially extends in contact with the adjacent carcass ply 3.

[0117] The annular insert 32 is made up of at least one metallic wire wound up to form several substantially concentric coils 32a. Coils 32a can be defined by a continuous spiral or by concentric rings formed of respective metallic wires.

[0118] Advantageously, during the tyre use, the inextensible annular insert 32 is adapted to efficiently counteract the bead tendency to rotate about the profile in transverse section of the bead core 31, under the effect of slip thrusts directed parallelly to the rotation axis of tyre 1. This tendency to rotation is particularly apparent when the tyre is employed under conditions of partial or total deflation.

[0119] Preferably, for accomplishment of each annular structure 4, first the inextensible annular insert 32 is formed within a moulding cavity 34 defined in a mould

34a, 34b, by deposition of at least one thread-like element in concentric coils 32a disposed in mutual side by side relationship, according to circumferences of increasingly growing diameter about their geometric winding axis corresponding to the rotation axis of the tyre.

[0120] This operation can be advantageously performed by winding the thread-like element in a helical seating arranged in a first cheek 34a of mould 34a, 34b which for the purpose can be driven in rotation about its own geometric axis.

[0121] The deposition step of the thread-like element can be advantageously preceded by a rubberizing step in which the thread-like element, preferably of metallic material, is coated with at least one layer of raw elastomeric material that, in addition to ensuring an excellent rubber-metal bond on the thread-like element itself, promotes adhesion thereof for a steady placement in the above mentioned helical seating.

[0122] The first cheek 34a may be also advantageously provided to be made of a magnetic material, or to be activated in an electromagnetic manner so as to attract and retain the thread-like element against itself, thereby ensuring a steady positioning of the coils 32a formed by it.

[0123] The bead core 31 is then located within the moulding cavity 34 and afterwards closure of the moulding cavity 34 is carried out by moving the first cheek 34a close to a second matching cheek 34b. The moulding cavity 34 is then filled with a raw elastomer material adapted to form a filling body 33 intimately joined to the bead core 31 and the circumferentially inextensible annular insert 32.

[0124] Preferably, filling of the mould 34 cavity is carried out by injecting the raw elastomer material through at least one annular injector comprising an admission opening or hollow space 35 substantially extending over the whole circumferential extension of the moulding cavity. In this way, a quick and homogeneous filling of the moulding cavity 34 occurs, without the risk of stratification phenomena that could arise in the elastomer material if the latter would be obliged to pass through admission channels of reduced section. It is to note that the admission hollow space 35 may be comprised of a plurality of slits homogeneously distributed along the whole circumferential extension of the moulding cavity 34, so as to give rise, in any case, to a quick and homogeneous filling of the moulding cavity.

[0125] Accomplishment of the inextensible annular structures 4 may advantageously take place close to the toroidal support 11, so that said structures lend themselves to be picked up and laterally applied to the carcass ply 3 by appropriate mechanical handling devices not described as not of importance to the aims of the invention.

[0126] When application of the inextensible annular structures 4 has been completed, either the carcass ply or plies, or, within the scope of the present invention, the

side portions 23a, 23c, 24a, 24c of the deposition sections 23, 24 are provided to have respective end flaps radially projecting towards the geometric rotation axis of the toroidal support 11 relative to the inextensible annular structures. These end flaps, substantially identified close to said bending regions 25, are turned back about the respective inextensible annular structures 4, as viewed from Fig. 8.

[0127] This turning-back step can be for example carried out with the aid of inflatable chambers or equivalent means associated with the toroidal support 11. The amount by which said end flaps project and consequently the width of the turned-back flap formed by same can be easily established in advance by suitably adjusting the radial-movement stroke of the distributor element 22 or the radial positioning of the retention elements 26, so as to modify the width of the side portions 23a, 23c, 24a, 24c in a radial direction.

[0128] Accomplishment of the carcass structure 2 can involve formation of at least one auxiliary carcass ply, not shown in the accompanying drawings. This auxiliary carcass ply can be directly formed in superposed relationship upon the carcass ply 3 and the inextensible annular structures 4, in the same manner as the primary carcass ply, optionally with deposition sections disposed in a crossed orientation relative to the deposition sections 23, 24 forming the first carcass ply 3.

[0129] In tyres of the radial type, a belt structure 5 is currently applied to the carcass structure 2.

[0130] Advantageously, in a novel and inventive manner, application of the belt structure 5 is provided to be substantially directly carried out on the carcass structure 2 which in a preferred embodiment of the invention can be made as previously described.

[0131] For the purpose, as diagrammatically shown in Figs. 9 and 10, formation of at least one continuous belt ribbon 36 is provided, which comprises a plurality of longitudinal parallel cords 36a, of metallic material for example, at least partly incorporated into one or more layers of raw elastomer material 36b.

[0132] Formation of the continuous belt ribbon 36 can be achieved for example by guiding the cords 36a, fed from respective reels 37, through a second extruder 38, into which the elastomer material from a second extrusion apparatus 39 flows. The continuous belt ribbon 36 emerging from the second extruder 38, after possible passage through first calendering rollers 40, is caused to pass through a cutting-off machine 41 cutting it according to a given inclination α relative to its longitudinal extension, to form belt lengths 42 the size in width of which, measured perpendicularly to the cutting direction, corresponds to the width of at least one first belt strip 6 to be obtained on the carcass structure 2.

[0133] Lengths 42 are individually and sequentially laid down onto the carcass structure 2 consecutively in a circumferential alignment and in mutual side by side relationship along respective junction edges 42a parallel to cords 36a and corresponding to the opposite lon-

itudinal edges of the belt ribbon 36.

[0134] Therefore the assembly of lengths 42 forms the first belt strip 6 of a continuous circumferential extension. As diagrammatically shown in Fig. 11, in the first belt strip 6 cords 36a will be disposed transversely at an inclination corresponding to the cutting inclination of lengths 42.

[0135] Preferably this inclination has a value corresponding to 80° and in any case included between 45° and 90° relative to the circumferential extension direction, optionally with an opposite orientation relative to the underlying carcass ply 3.

[0136] In order that the first belt strip 6 consisting of lengths 42 of same extension may have a homogeneous and continuous circumferential course, the continuous belt ribbon 36 emerging from the second extruder 38 may be provided to have a transverse extension, measured parallelly to the cutting direction, equal to a submultiple of the circumferential extension of the first belt strip. Alternatively, said transverse extension may be provided to be slightly lower than the value of the above mentioned submultiple, being then suitably increased by the calendering action carried out by rollers 40.

[0137] In conclusion, by suitably intervening on the calendering rollers 40, the width of the continuous belt ribbon 36 may be adapted in such a manner that the obtained lengths 42 shall have an extension corresponding to a submultiple of the circumferential course of the belt strip 6 to be made, without replacement of extruder 38 being required.

[0138] It is to point out that by the calendering operation, an increase in the distance between the individual cords 36a is obtained, concurrently with an increase in width of the continuous belt ribbon 36, said individual cords 36a remaining in any case spaced apart the same distance from each other.

[0139] The above described operating sequence can be repeated in the same manner if formation of one or more additional first belt strips, not shown in the accompanying drawings, is required, the cords of which would be inclined according to a crossed orientation relative to the cords 36a of the first belt strip 6 and/or adjacent strips.

[0140] In a manner known per se, formation of the first belt strip or strips 6 can be preceded by application of two strip-like inserts 43 adapted to support the opposite side edges of the first belt strips so that the latter may substantially keep a flat profile in transverse section.

[0141] Therefore, at least one second belt strip 7 is made, preferably by winding of at least one continuous elongated element 44 in the form of coils disposed axially in side by side relationship and extending circumferentially about the first belt strip 6.

[0142] If required, the winding coils formed by the elongated element 44 can be disposed side by side in a variable axial distribution pitch, which for instance is greater close to the equatorial median plane X-X of the

tyre relative to the opposite side edges of the belt structure 5.

[0143] As diagrammatically shown in Fig. 12, for preparation of the continuous elongated element 44, one or more elementary cords 44a fed from corresponding reels 45, are parallelly joined together and rubberized by passage through a third extruder 46 supplied with elastomer material from a third extrusion apparatus 47.

[0144] The elongated element 44 thus obtained has one or more elementary cords 44a coated with an elastomer material of appropriate thickness and is ready to be wound around the first belt strip 6, after possible passage through a storage device 48.

[0145] In a convenient embodiment, said cords are the well known metallic cords of the HE (high ultimate elongation) type, use and features of which have already been widely described in the European Patent 0 461 464 in the name of the same Applicant, for example.

[0146] In more detail, these cords consist of a given number of strands, each strand being formed of a given number of individual wires of a diameter not lower than 0.10 mm and not higher than 0.40 mm, preferably included between 0.12 and 0.35 mm. Wires in the strands and strands in the cord are helically wound together in the same direction, the winding pitches for wires and strands being the same or even different.

[0147] Preferably, these cords are made of high-carbon (HT) steel wires, i.e. containing carbon to an extent not lower than 0.9%.

[0148] In a specific embodiment, particularly advantageous in the case of tyres for road haulage, said helical layer winding is preferably made of a single cord known as 3x4x0.20 HE HT cord spiralled from one belt end to the other: said indication identifies a metallic cord formed of 3 strands each consisting of four elementary wires of a diameter of 0.20 mm wound in the same direction as the strands; then, as known, abbreviation HE stands for "high elongation" and abbreviation HT stands for "high tensile".

[0149] These cords have an ultimate elongation included between 4% and 8% and a well-known typical behaviour under tension, a so-called "spring behaviour".

[0150] In an alternative embodiment, specifically adopted with tyres for cars, said winding is carried out with textile cords preferably of a heat-shrinkable material, such as NYLON 6 or NYLON 66 for example.

[0151] Then the tread band 8 is applied to the belt structure 5 obtained in the above described manner.

[0152] In more detail, according to a further aspect of the present invention, the tread band 8 is directly formed about the belt structure 5 by circumferential winding of at least one continuous sheet of raw elastomer material 49, about the belt structure in a plurality of radially superposed coils, as diagrammatically shown in Fig. 15.

[0153] The continuous sheet of elastomer material can be advantageously made with the aid of a fourth

extruder 50 supplied from a fourth extrusion apparatus 51. Sheet 49 emerging from the fourth extruder 50 can be engaged by a further calendering unit 52, immediately downstream of which the toroidal support 11 carrying the tyre being manufactured may be arranged, to enable direct winding of the elastomer sheet around the belt structure 5.

[0154] By appropriate cutting means associated with the calendering unit 52 and/or by shutting means operating at the outlet of the fourth extruder 50 (both not shown as they can be made in any convenient manner for a person skilled in the art), the width of the elastomer material sheet 49 can be advantageously progressively reduced concurrently with formation of each winding coil "S" around the belt structure 5, so that the elastomer sheet has a progressively decreasing width away from the rotation axis of tyre 1. Actually, with reference to Fig. 15, it can be easily assumed that the radially outer coils "S" have a smaller width than the radially innermost coils, so as to give the obtained tread band 8 a desired transverse profile.

[0155] After accomplishment of the tread band 8 or optionally before this operating step, application of sidewalls 9 made in the manner diagrammatically shown in Figs. 16 and 17, is carried out. In the embodiment shown, each sidewall 9 is made by injection of elastomer material into another mould 53, from which said sidewall is taken up and subsequently laterally applied to the carcass structure 2 with the aid of mechanical handling devices or the like.

[0156] In the embodiment shown, each sidewall 9 has a radially outer portion 9a and a radially inner portion 9b made of different types of elastomer material and intimately joined together by an overmoulding process. For the purpose, mould 53 essentially has an outer cheek 53a and a pair of inner cheeks 53b which are mutually interchangeable and only one of which is shown in the drawings.

[0157] The outer cheek 53a is first coupled with a first inner cheek (not shown) to define a first cavity within the mould, in which cavity by injection of a first elastomer material, the radially outer portion 9a of the sidewall 9 is formed. The inner cheek of mould 53 is then replaced by the second inner cheek 53b such shaped that in the mould a second cavity partly delimited by the previously-moulded radially outer portion 9a is defined. This second seating is intended for receiving the radially inner portion 9b which is formed by injection of a second elastomer material.

[0158] Each of the sidewalls 9 formed in the above described manner lends itself to be laterally applied to the carcass structure 2, as above described.

[0159] Tyre 1 thus manufactured is now ready to be removed from the toroidal support 1 to be submitted to a vulcanization step that can be executed in any known and conventional manner.

[0160] According to a possible alternative embodiment, an air tube of closed tubular section may be

advantageously associated with tyre 1 in addition to, or in place of liner 10, before the vulcanization step, which air tube is inserted into carcass 2 after the tyre has been removed from the toroidal support 11. This air tube, not shown in the accompanying drawings, will be inflated after the tyre has been introduced into a vulcanization mould, to supply an inner pressure adapted to ensure a perfect adhesion of the tyre against the mould walls and, in particular, against the mould parts intended for defining the longitudinal and transverse cuts 8a of the tread pattern.

[0161] According to a further preferential feature of the present invention, during the vulcanization step the carcass plies 3 and belt strips 6, 7 are submitted to a stretching step to achieve a pre-tensioning thereof, giving rise to a tyre expansion according to a linear extent measured on the circumferential extension at the equatorial plane X-X of the tyre itself included, just as an indication, between 2% and 5%. This stretching step can be achieved by effect of the inflation pressure of the above mentioned air tube, or other type of inflatable chamber or bladder employed in the vulcanization apparatus.

[0162] The present invention achieves important advantages.

[0163] Actually, the tyre in reference can be obtained through manufacture of the different components directly on a toroidal support on which the tyre is gradually formed or in any case very close thereto. In this way all problems connected with manufacture, storage and management of semi finished products which are common to manufacturing processes of the traditional type are eliminated.

[0164] It is to note in particular that formation of the carcass ply or plies by deposition of a strip-like element formed of several cords incorporated into one elastomer layer enables important advantages to be achieved. First of all, in comparison with the method described in the above mentioned US Patent 5,453,140, the manufacturing time for each carcass ply can be greatly reduced, due to the simultaneous deposition of as many thread-like elements as they are contained in the strip-like element 13. Employment of the strip-like element 13 also dispenses with the need for previously depositing liner 10 onto the toroidal support. Actually, the elastomer layer 13b employed in forming the strip-like element 13 is capable by itself to ensure an efficient adhesion of element 13 to the toroidal support 11, thereby ensuring a steady positioning of the individual deposition sections 23, 24.

[0165] Positioning accuracy as regards the deposition sections and the thread-like elements integrated therein is further improved by the fact that the strip-like element has an important structural consistency that makes it insensitive to vibrations or similar oscillation effects that can be transmitted by the deposition apparatus 28. In this connection it is to note that deposition of an individual thread-like element, as described in US Patent No. 5,453,140, makes it difficult to obtain an

accurate deposition of each thread section, due exactly to vibrations and/or oscillations undergone by said thread during the deposition step.

[0166] Furthermore, simultaneous deposition of a plurality of thread-like elements in accordance with the invention enables the deposition apparatus 28 to be operated at slower rates than required when deposition of the individual thread is concerned, which is a further advantage in terms of working accuracy without on the other hand impairing productivity.

[0167] Besides, deposition of a strip-like element directly crownwise to a toroidal support of a profile substantially identical with that of the finished tyre enables densities to be achieved that cannot be reached in the art by known methods providing deposition of a carcass ply in the form of a cylindrical sleeve and subsequent shaping of same into a toroidal form, which will consequently bring about thinning of the carcass ply cords disposed crownwise to the finished tyre.

[0168] In addition to the above, the strip-like element can be steadily fastened to the toroidal support by a vacuum effect produced through possible suction ducts 28, which steady fastening by vacuum cannot be achieved by known processes carrying out deposition of an individual thread.

[0169] The inclined arrangement of side portions 23a, 23c, 24a, 24c enables expansion undergone by the tyre during the stretching step imposed to it on vulcanization to be efficiently helped. Actually, during this step, the side portions tend to take an orientation in a plane radial to the tyre together with the crown portions 23b, 24b extending between the side portions.

[0170] Mutual superposition of the side portions close to the rotation axis of the tyre greatly strengthen the tyre structure close to beads, where a greater structural strength is usually required.

[0171] Attention is also drawn to the original construction character of the inextensible annular structures 4 disposed at the beads. In particular, due to the presence of the circumferentially inextensible annular inserts 32 combined with conventional bead cores 31, tendency of the bead to rotate by effect of slip thrusts is efficiently prevented. In the known art, this phenomenon led the tyre to slip off the respective security hump arranged in the rim, above all when the tyre was submitted to slip thrusts under partial-deflation conditions. By arrangement of the annular inserts 32, this drawback is eliminated and the tyre lends itself to be employed even under conditions of practically complete deflation without the occurrence of undesired removal of the bead from its seat.

[0172] Behaviour of the tyre bead in accordance with the present invention during running in slip is diagrammatically shown in Fig. 19, showing tyre 1 in transverse half-section, associated with a standard mounting rim 54 which, at each of the tyre beads, has a bead seat 55 axially delimited by a flange 56 defining an outer side edge of the rim and a security hump 57. For the sake of

clarity, section hatching has been purposely omitted from tyre 1 shown in Fig. 19.

[0173] As can be easily viewed from said figure, the presence of the inextensible annular insert 32 prevents the tyre bead from rotating under the effect of the slip thrust N directed parallelly to the tyre axis, turning on its resting point against the security hump 57 arranged in rim 54. Under this situation the slip thrust N, transmitted along the carcass ply 3 until close to the bead rim 31, gives rise to a radial component N_1 which tends to move the bead away from the bead seat 55 and is counteracted by the circumferential inextensibility of the annular structure 4, as well as to an axial component N_2 tending to push the bead against the circumferential flange 56 ensuring maintenance of a steady positioning of same.

[0174] In this way the tyre having beads made in accordance with the present invention lends itself to bear the so-called "J-curve Test" without removal of the bead from its seat until inflation pressures of 0.5 bar, whereas in the known art tyres that are unable to counteract bead displacements from their seats at pressures lower than 0.8-1.0 bar are considered as acceptable.

[0175] It is also to note that annular inserts 32 supply a further structure protection to the tyre at the beads.

Claims

1. A method of making a tyre, comprising the steps of:

- making a carcass structure (2);
- applying a belt structure (5) to the carcass structure (2) at a circumferentially external position thereof;
- applying a tread band (8) to the belt structure (5) at a circumferentially external position thereof;
- applying at least one pair of sidewalls (9) to the carcass structure (2) at laterally opposite positions;
- vulcanizing the obtained tyre (1), characterized in that manufacturing of the carcass structure (2) involves formation of at least one carcass ply (3) by the following steps:
 - preparing at least one continuous strip-like element (13) comprising a plurality of longitudinal and parallel thread-like elements (13a) at least partly coated with at least one layer of raw elastomer material (13b);
 - depositing the strip-like element (13) onto a toroidal support in alternated deposition sections (23, 24) each extending in a substantially U-shaped conformation about the profile in transverse section of the toroidal support (11), to define two side portions (23a, 23c, 24a, 24c) substantially extending in planes orthogonal to a geometric axis of rotation of the toroidal support (11) at mutually spaced apart positions in an axial direction, and a crown portion (23b,

- 24b) extending in a radially external position between the side portions (23a, 23c, 24a, 24c);
 - the crown portions (23b, 24b) of each deposition section (23, 24) being disposed consecutively in side by side relationship along the circumferential extension of the toroidal support (11), whereas the side portions (23a, 23c, 24a, 24c) of each deposition section (23, 24) are each partly overlapped with a side portion of at least one consecutive deposition section.
2. A method as claimed in claim 1, wherein the side portions (23a, 23c, 24a, 24c) in mutual-overlapping relationship are caused to mutually converge at the geometric axis of rotation of the toroidal support (11).
 3. A method as claimed in claim 1, wherein mutual overlapping of the side portions (23a, 23c, 24a, 24c) of the deposition sections (23, 24) progressively decreases starting from a maximum value at the radially inner ends of the side portions until a zero value at transition regions between said side portions and crown portions (23b, 24b).
 4. A method as claimed in claim 1, wherein the side portions (23a, 23c, 24a, 24c) in mutual-overlapping relationship are maintained joined to each other at a bending end region (25) where the strip-like element (13) is folded upon itself.
 5. A method as claimed in claim 1, wherein the individual deposition sections (23, 24) are sequentially laid down onto the toroidal support (11) according to a circumferential distribution pitch corresponding to the width of the strip-like element (13).
 6. A method as claimed in claim 1, wherein the individual deposition sections (23, 24) are sequentially laid down onto the toroidal support (11) according to a circumferential distribution pitch corresponding to a multiple of the width of the strip-like element (13).
 7. A method as claimed in claim 1, wherein the strip-like element (13) has a width corresponding to a submultiple of the circumferential extension of the toroidal support (11), as measured at its equatorial plane.
 8. A method as claimed in claim 1, wherein manufacturing of said at least one carcass ply (3) further involves a sequential pressing step of the strip-like element (13) at the side portions (23a, 23c, 24a, 24c) of the deposition sections (23, 24), to define regions of greater width close to the inner circumferential edges of the carcass structure (2).
 9. A method as claimed in claim 8, wherein the pressing step is carried out on the strip-like element (13) during the deposition step, by exerting a pressing action of the strip-like element at a section thereof upstream of the toroidal support (11).
 10. A method as claimed in claim 8, wherein concurrently with said pressing step, moving apart from each other of the thread-like elements (13a) comprised in the strip-like element (13) is carried out.
 11. A method as claimed in claim 1, wherein during the deposition step, at least one deposition section comprising an initial or leading end of the strip-like element is retained on the toroidal support (11) by a suction action produced through the toroidal support itself.
 12. A method as claimed in claim 1, wherein formation of each deposition section (23, 24) involves the steps of:
 - guiding the strip-like element (13) on a distributor element (22) movable about the profile in transverse section of the toroidal support (11);
 - translating the distributor element (22) substantially radially away from the geometric axis of rotation of the toroidal support (11) to form a first side portion (23a, 24a) of the deposition section (23, 24) of the strip-like element (13);
 - rotating the toroidal support (11) relative to the distributor element (22) according to an angular pitch corresponding to half the distribution pitch of the deposition sections (23, 24), concurrently with formation of said first side portion (23a, 24a);
 - translating the distributor element (11) substantially in a direction parallel to the geometric axis of rotation of the toroidal support (11) to form the crown portion (23b, 24b) of the deposition section (23, 24) of the strip-like element (13);
 - translating the distributor element (22) substantially radially close to the geometric axis of rotation of the toroidal support (11) to form a second side portion (23c, 24c) of the deposition section (23, 24) of the strip-like element (13);
 - rotating the toroidal support (11) relative to the distributor element (22) according to said angular pitch, concurrently with formation of said second side portion (23c, 24c).
 13. A method as claimed in claim 12, wherein during formation of the first side portion (23a, 24a) of each deposition section (23, 24) the step of retaining the strip-like element (13) at a bending region (25) defined between the first side portion and the sec-

ond side portion (23a, 24a) of the previously formed deposition section is carried out.

14. A method as claimed in claim 13, wherein retention of the strip-like element (13) is carried out by disposing a retaining element (26) alongside the second side portion (23a, 24a) after translation of the distributor element (22) radially close to the geometric axis of rotation of the toroidal support (11), so that the strap-like element (13) is turned back about the retaining element (26) thereby forming the bending region (25) as a result of translation of the distributor element (22) radially away from the geometric axis of rotation of the toroidal support (11).
15. A method as claimed in claim 14, wherein the retaining element (26) is axially disengaged from the bending region (25), after starting of formation of the crown portion (23b, 24b) of the deposition section (23, 24) being made.
16. A method as claimed in claim 1, further comprising a step of pressing said side portions (23a, 23c, 24a, 24c) of the deposition sections against side walls of the toroidal support (11).
17. A method as claimed in claim 16, wherein said pressing step is carried out repeatedly on a first and a second side portions (23a, 24c, 23c, 24a) belonging to two contiguous deposition sections (23, 24).
18. A method as claimed in claim 1, wherein accomplishment of the carcass structure (2) further comprises the step of applying at least one inextensible annular structure (4) to an area close to each of the inner circumferential edges of the carcass ply (3) obtained from the deposition step.
19. A method as claimed in claim 18, wherein accomplishment of the carcass structure (2) further comprises the step of turning back end flaps of the side portions (23a, 23c, 24a, 24c) about the respective inextensible annular structures (4).
20. A method as claimed in claim 1, wherein accomplishment of the carcass structure (2) further comprises the step of forming a second carcass ply in the same manner as formation of the first carcass ply (3).
21. A method of making a tyre, comprising the steps of:
 - making a carcass structure (2);
 - applying a belt structure (5) to the carcass structure (2) at a circumferentially external position thereof;
 - applying a tread band (8) to the belt structure
- (5) at a circumferentially external position thereof;
- applying at least one pair of sidewalls (9) to the carcass structure (2) at laterally opposite positions;
- vulcanizing the obtained tyre (1), characterized in that accomplishment of each inextensible annular structure (4) comprises the steps of:
 - depositing at least one thread-like element in concentric coils (32a) into a moulding cavity (34) to form a circumferentially inextensible annular insert to be positioned substantially parallelly to adjacent surfaces of the carcass ply (3);
 - positioning an annular anchoring element (31) into the moulding cavity (34), at a position axially close to the circumferentially inextensible annular insert (32);
 - injecting raw elastomeric material into the moulding cavity (34) to make a filling body (33) intimately joined to the annular anchoring element (31) and the circumferentially inextensible annular insert (32).
22. A method as claimed in claim 21, wherein said deposition step is preceded by a rubberizing step in which said thread-like element is coated with at least one layer of raw elastomer material.
23. A method as claimed in claim 21, further comprising the step of magnetically retaining the circumferentially inextensible annular insert (32), at a predetermined position, within the moulding cavity (34).
24. A method as claimed in claim 21, wherein injection of the raw elastomer material is carried out through at least one circumferential admission hollow space (35) opening into the moulding cavity (34).
25. A method of making a tyre, comprising the steps of:
 - making a carcass structure (2);
 - applying a belt structure (5) to the carcass structure (2) at a circumferentially external position thereof;
 - applying a tread band (8) to the belt structure (5) at a circumferentially external position thereof;
 - applying at least one pair of sidewalls (9) to the carcass structure (2) at laterally opposite positions;
 - vulcanizing the obtained tyre (1), characterized in that application of the belt structure (5) comprises the steps of:
 - forming at least one continuous belt ribbon (36) comprising at least one layer of raw elastomer material (36b) at least partly incorporating a

- plurality of longitudinal parallel cords (36a);
- cutting said continuous belt ribbon (36) according to a predetermined inclination relative to its longitudinal extension to form belt lengths (42) having a predetermined size in width, measured perpendicularly to the cutting direction;
 - laying down the belt lengths (41) consecutively in circumferential alignment onto the carcass structure (2) to form at least one first continuous belt strip (6) having said cords (36a) disposed transversely according to an inclination corresponding to the cutting inclination of said lengths (42).
26. A method as claimed in claim 25, wherein before said cutting step, the continuous belt ribbon (36) is submitted to a calendering step to give said lengths a circumferential size corresponding to a submultiple of the circumferential extension of the belt strip (6).
27. A method as claimed in claim 25, wherein application of the belt structure (5) further comprises the step of forming at least one second belt strip (7) by winding of at least one continuous thread-like element (44) in coils disposed axially in side by side relationship and extending circumferentially about the first belt strip (6).
28. A method as claimed in claim 27, wherein the winding coils formed by the elongated element (44) are disposed mutually in side by side relationship according to a variable axial-distribution pitch.
29. A method as claimed in claim 28, wherein said axial-distribution pitch is greater close to the equatorial median plane (X-X) of the tyre (1) relative to the opposite side edges of the belt structure (5).
30. A method as claimed in claim 1, wherein application of the tread band (8) comprises the step of circumferentially winding at least one continuous sheet of raw elastomer material (49) about the belt structure (5) in a plurality of radially superposed coils (S).
31. A method as claimed in claim 30, wherein the continuous sheet of elastomer material (49) is produced directly during its application to the belt structure (5).
32. A method as claimed in claim 30, further comprising the step of progressively reducing the width of the elastomer material sheet (49), concurrently with formation of each winding coil (S) about the belt structure (5).
33. A method as claimed in claim 1, wherein each of said sidewalls (9) is made by injection of elastomer material into a mould (53).
34. A method as claimed in claim 33, wherein accomplishment of each of said sidewalls (9) comprises the following steps:
- injecting a first elastomer material into a first cavity defined in said mould (53) to form a radially outer portion (9a) of the sidewall (9);
 - defining a second cavity in the mould (53), which is partly delimited by the radially outer portion (9a) of the sidewall (9);
 - injecting a second elastomer material into the second cavity of the mould (53) to define a radially inner portion (9b) of the sidewall (9).
35. A method as claimed in claim 1, wherein formation of the carcass ply (3) is preceded by a step of coating the toroidal support (11) with at least one air-proof layer or liner (10) of elastomer material.
36. A method as claimed in claim 35, wherein said coating step is carried out by winding at least one ribbon-like band (12) of an air-proof elastomer material in coils disposed in side-by-side relationship along the profile in transverse section of the toroidal support (11).
37. A method as claimed in claim 1, wherein before the vulcanization step the following steps are carried out:
- disengaging the tyre (1) from the toroidal support (11);
 - inserting an air tube into the carcass structure (2).
38. A method as claimed in claim 1, wherein during said vulcanization step, a step of stretching said carcass plies (3) and belt strips (6, 7) is carried out for achieving an expansion of the tyre of a linear amount included between 2% and 5%.

FIG. 1

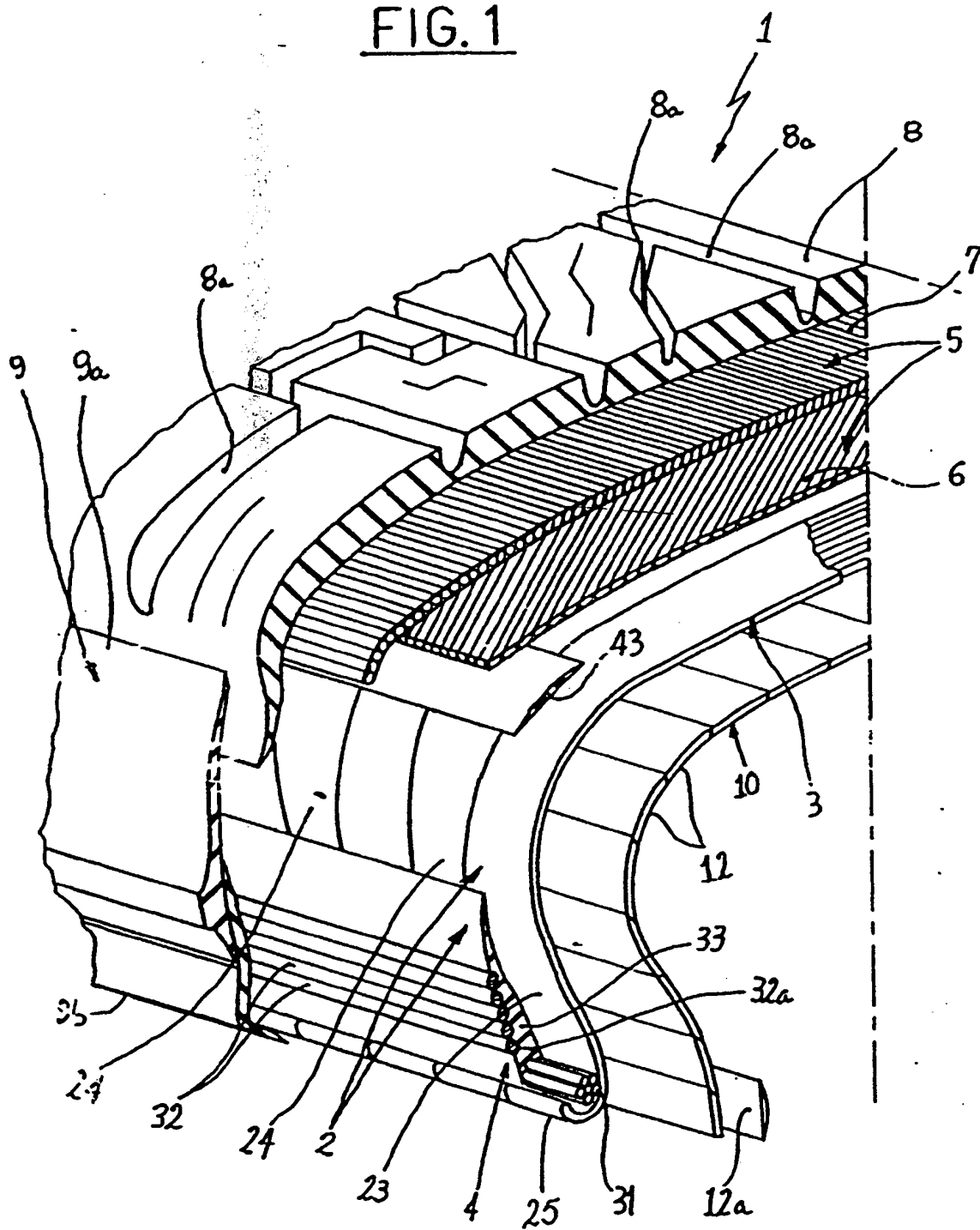


FIG. 2

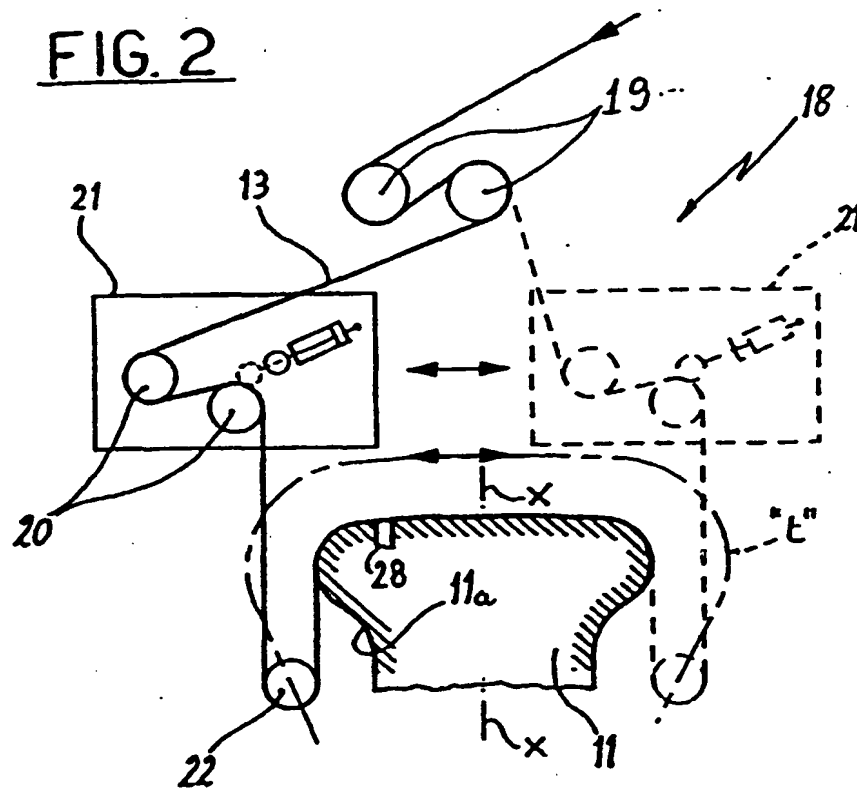
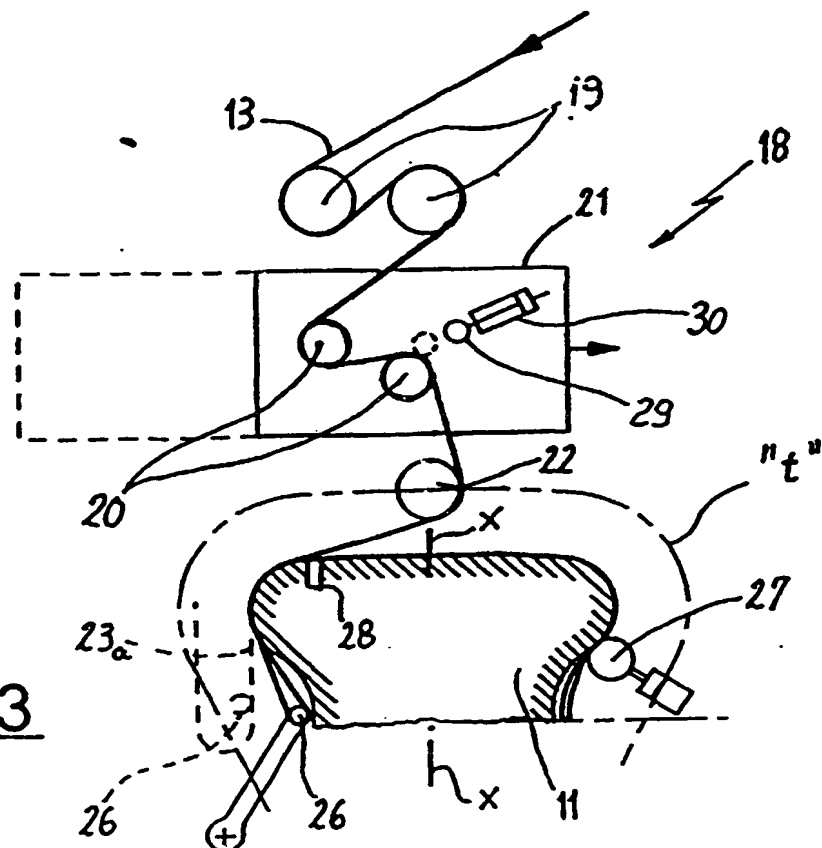


FIG. 3



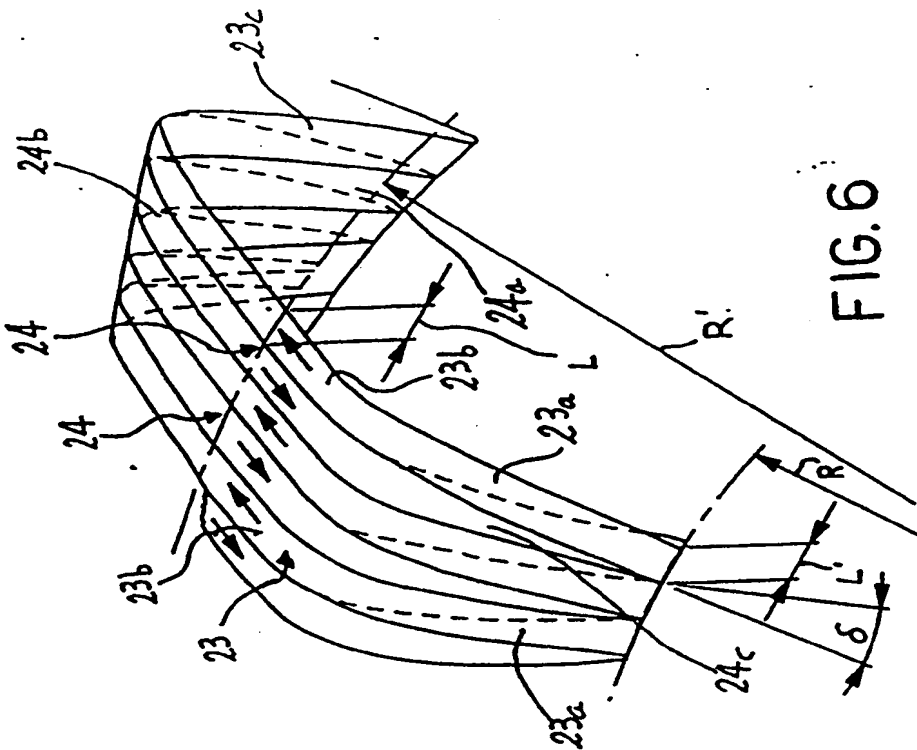


FIG. 6

FIG. 5

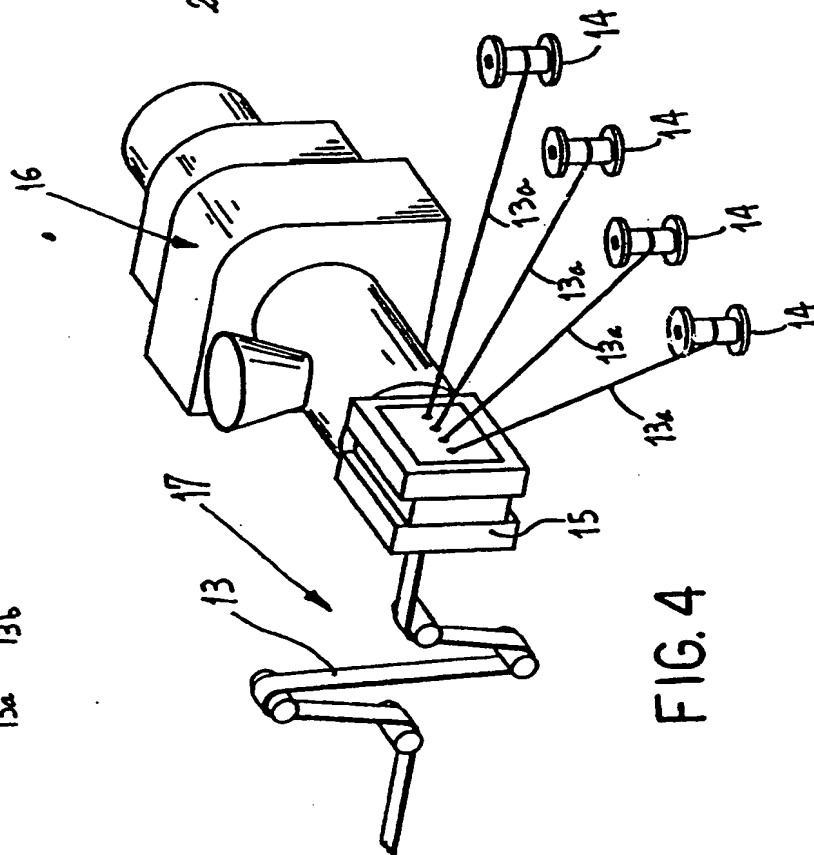
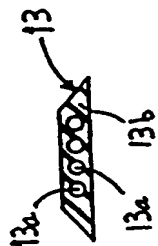
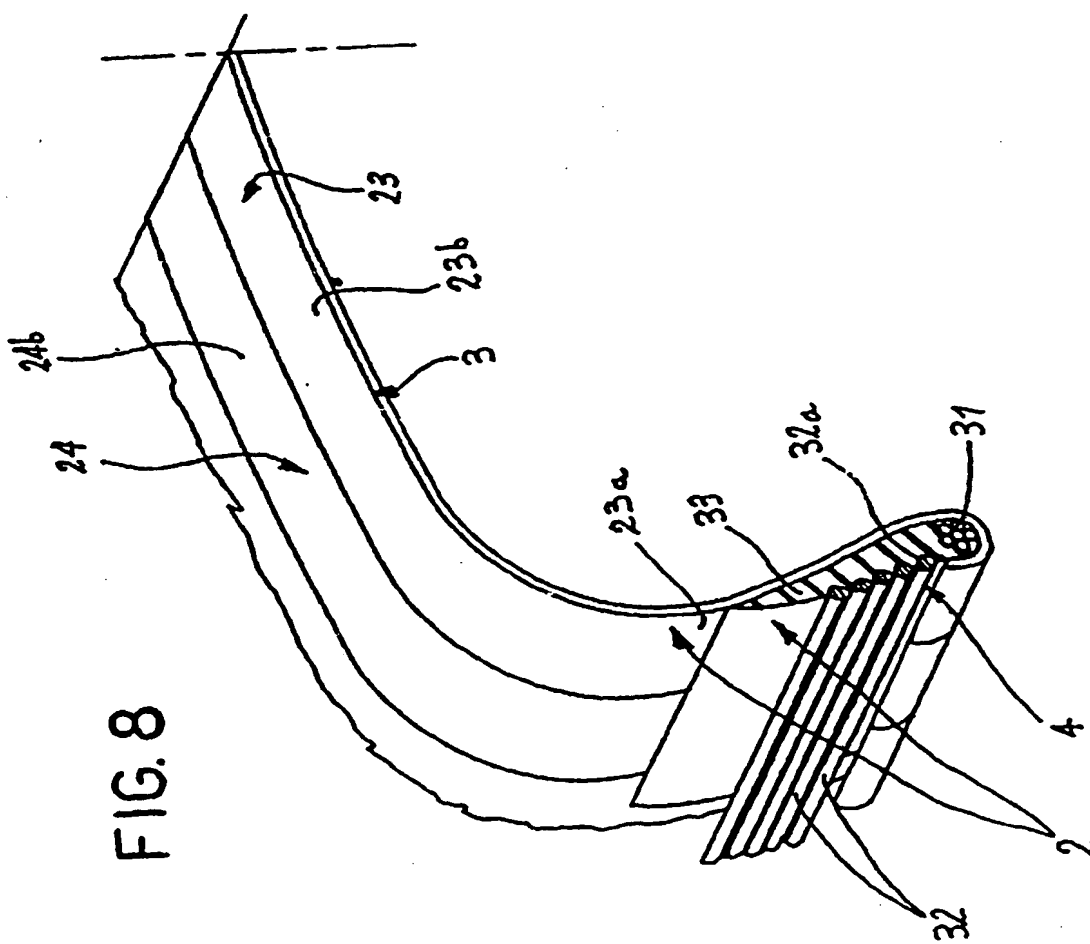
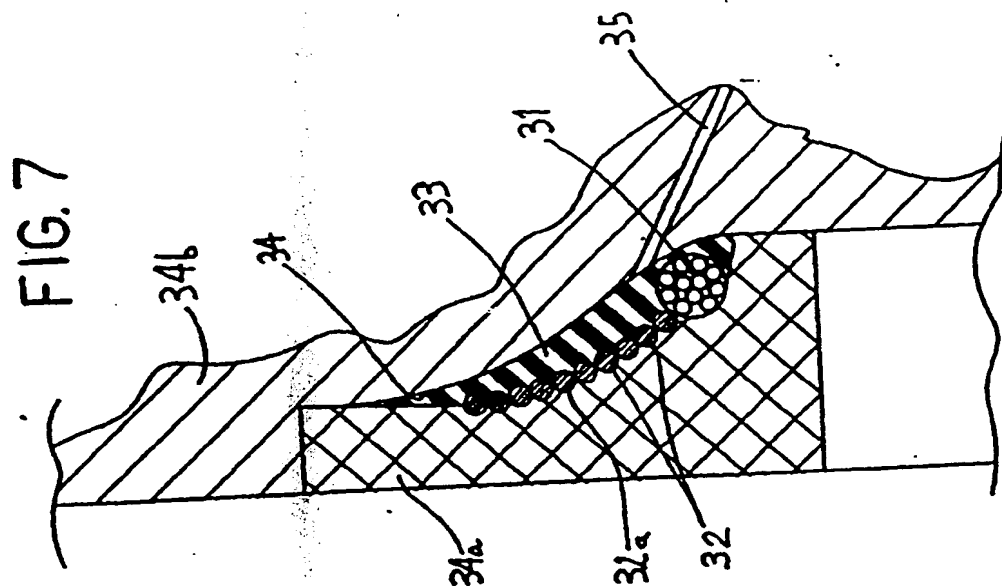
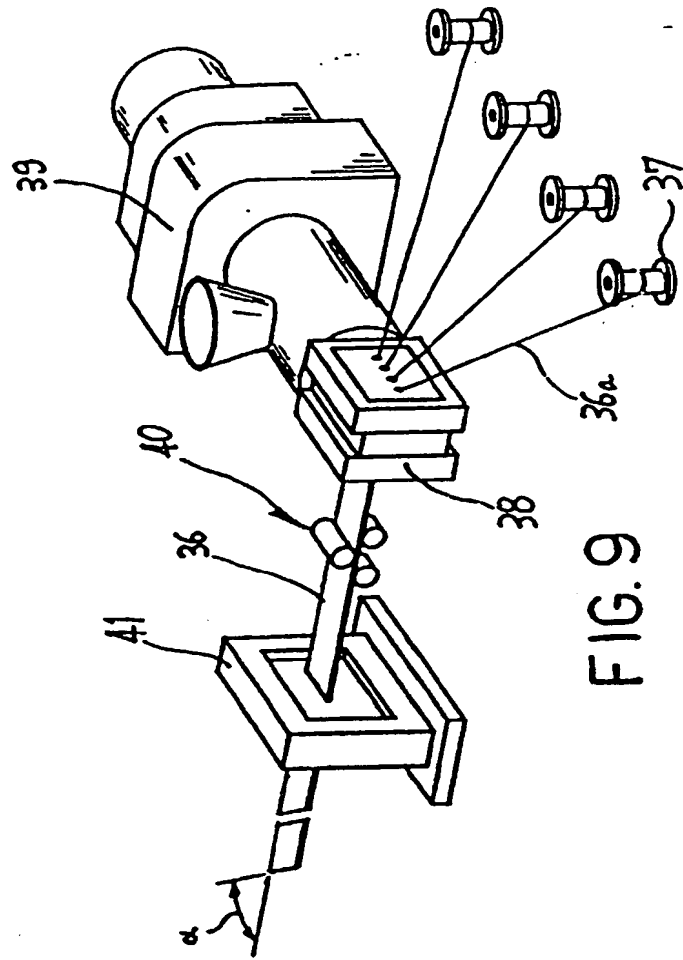
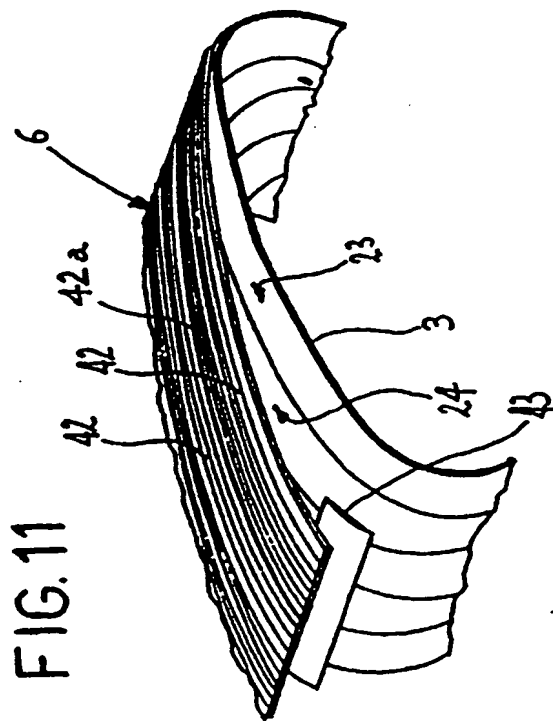
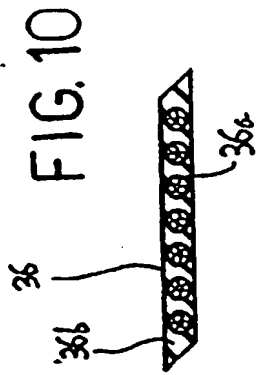
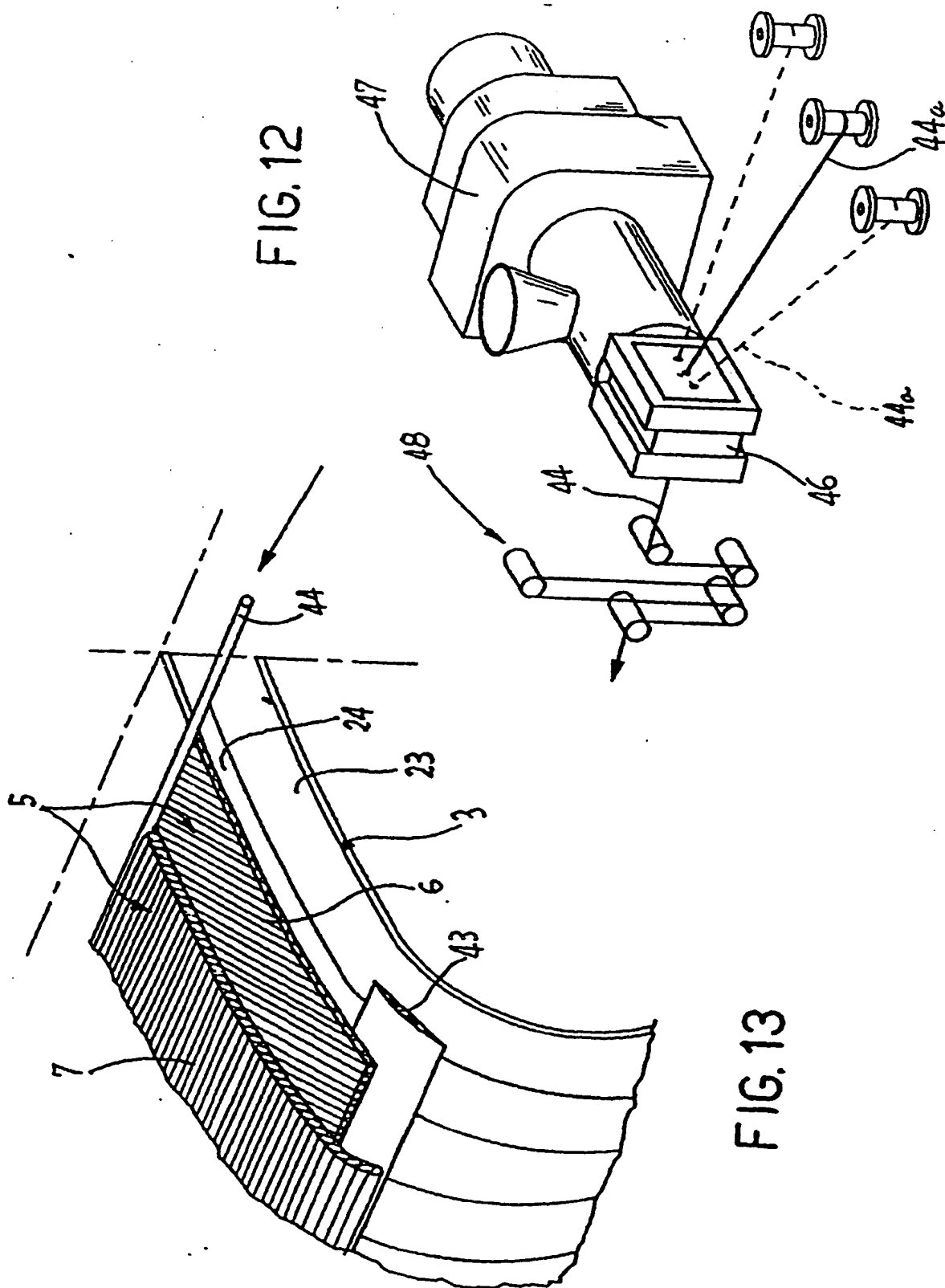


FIG. 4







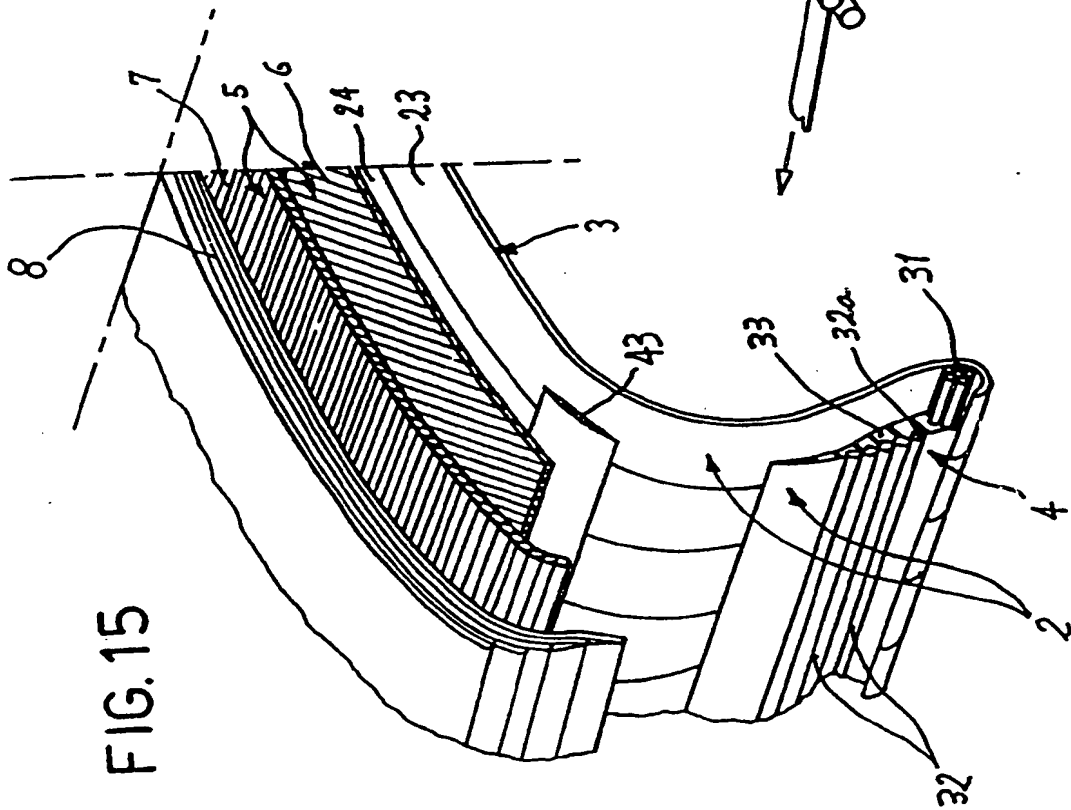


FIG. 14

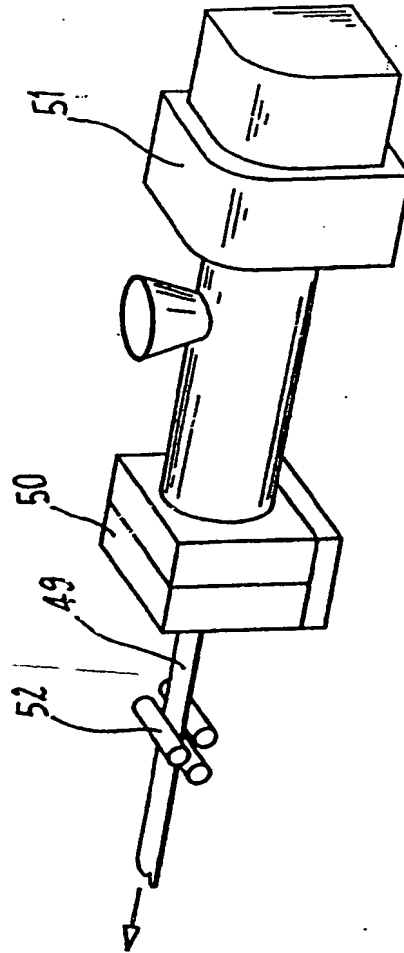


FIG. 16

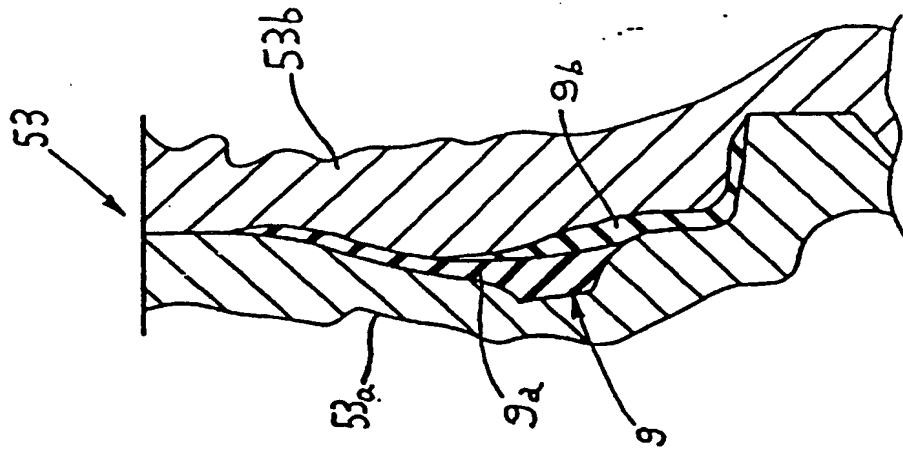


FIG. 17

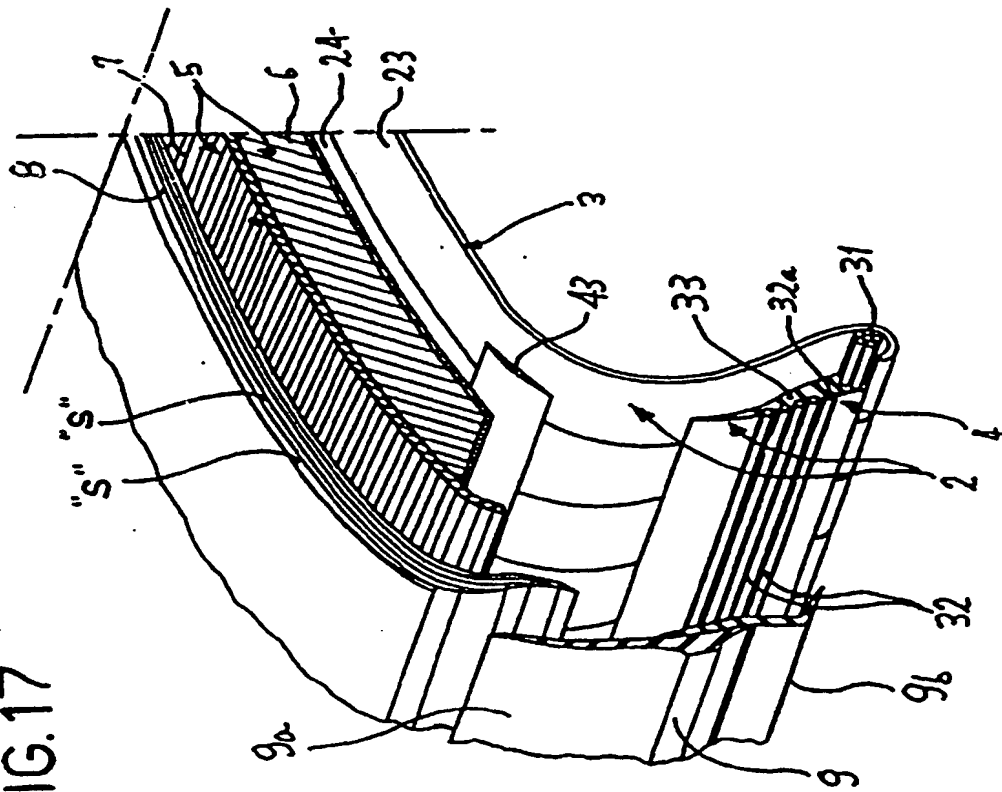


FIG.18

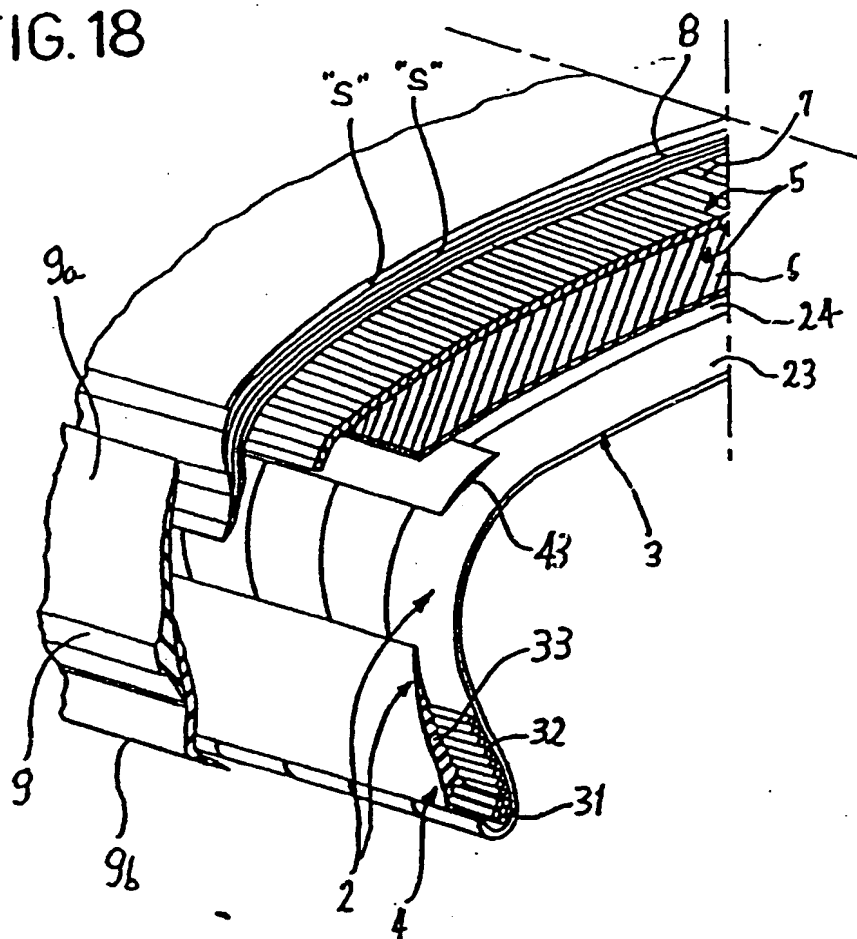
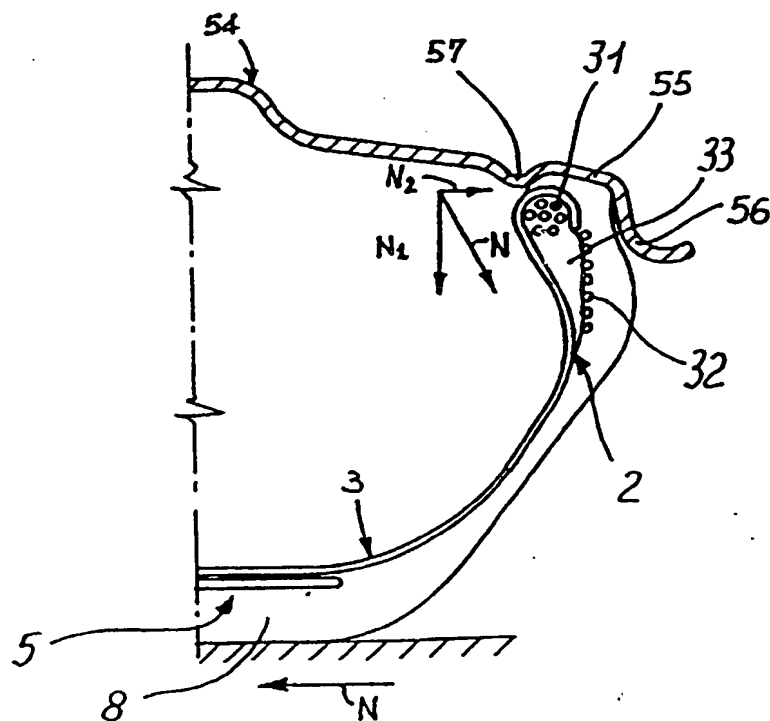


FIG.19





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 97 83 0633

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CI.6)
X	WO 89 02492 A (ARMSTRONG RUBBER CO)	1,2,4,5, 12,13, 18,19 30-35	B29D30/10 B29D30/16 B29D30/72 B29D30/70
Y	* page 7, line 8 - line 31; figures 1,2 * * page 7, line 32 - page 8, line 4 * * page 12, line 1 - page 16, line 9; figures 4A,4B * * claim 18 *		
Y	--- US 3 833 437 A (APPLEBY P ET AL) * the whole document *	30-32	
Y	--- FR 2 663 884 A (CONTINENTAL AG) * page 5, line 6 - line 13; figure 3 *	33,34	
Y	--- EP 0 481 805 A (BRIDGESTONE CORP) * column 5, line 7 - line 14; figure 3A *	35	
X	--- US 3 356 553 A (L. C. FRAZIER) * column 4, line 61 - line 73; figures 1-3 * * column 5, line 3 - line 45 * * column 6, line 65 - line 71 *	1-3,5-7, 18,30,38	TECHNICAL FIELDS SEARCHED (Int.CI.6) B29D
X	--- US 1 603 858 A (T. MIDGLEY) * page 3, line 121 - page 4, line 8; figures 88,89 * * page 27, line 16 - line 66 *	1,3,4, 12-14, 16,18,20 30,33	
A	--- -/--		
-The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 April 1998	Examiner FREGOSI, A
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document		T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 83 0633

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 1 603 855 A (T. MIDGLEY) * page 1, line 12 - line 55; figures 51-55 * * page 1, line 27 * * page 10, line 124 - page 11, line 3 *	1,3,4, 12-14,16	
A	FR 1 317 045 A (DUNLOP RUBBER LTD) * the whole document *	1,6-10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
-The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 April 1998	Examiner FREGOSI, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)



European Patent
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Application Number
EP 97 83 0633

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-20, 30-38



European Patent
Office

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number
EP 97 83 0633

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-20, 30-38

Method of manufacturing a pneumatic tyre comprising the step of manufacturing its carcass by depositing a continuous strip-like reinforcing element onto a toroidal support in alternated deposition sections.

2. Claims: 21-24

Method of manufacturing a pneumatic tyre in which an inextensible annular structure is manufactured in a mould.

3. Claims: 25-29

Method of manufacturing a pneumatic tyre comprising the step of manufacturing the belt structure by laying down onto the carcass cut belt lengths in circumferential alignment.